ANNALS of SURGERY

DIVERTICULA OF THE ŒSOPHAGUS, PULSION, TRACTION, MALIGNANT AND CONGENITAL*

By Chevalier Jackson, M.D.

AND

Thomas A. Shallow, M.D.

of Philadelphia, Pa.

ŒSOPHAGOSCOPIC OBSERVATIONS

BY CHEVALIER JACKSON

Incoördination of the Cricopharyngeal Pinchcock as an Etiologic Factor in Pulsion Diverticulum.—The cricopharyngeus muscle is in my opinion an important factor in the etiology of pulsion diverticulum (Figs. 1 and 2). These orbicular fibres of the inferior constrictor merge with the circular fibres of the œsophagus. Some anatomists seem to regard them as part of the inferior constrictor and other anatomists seem to regard them as circular fibres of the œsophagus. To the œsophagoscopist, however, the living active muscle looms in huge proportions because so long as it remains contracted, it acts as an impassable barrier to the safe passage of the œsophagoscope. Making gentle pressure with the tube-mouth he waits patiently until the cricopharyngeus relaxes sufficiently to allow the œsophagoscope to enter the œsophagus. No one who examines this region on the cadaver has any conception of the bone-like hardness of the mucosa-covered cricopharyngeus when contracted in a patient who is not under general anæsthesia. This hardness led early œsophagoscopists to think it was the cricoid cartilage that was encountered. The author, however, demonstrated [1] that the resistance was on the posterior wall and was due to the orbicular muscular fibres (Fig. 1) that are essentially different in power and action from either the circular fibres of the œsophagus, on the one hand, or the oblique fibres of the inferior constrictor on the other. To the author, looking through the œsophagoscope, it is obvious that the oblique fibres remain contracted while the orbicular fibres relax. This constitutes a separate action with distinct innervation that entities each group of muscular fibres to a separate name. The separate name serves well the study of the mechanism of deglutition and of the technic of introduction of the œsophagoscope. Passing on down with the œsophagoscope nothing similar to the cricopharyngeal constriction is found throughout the entire length of the thoracic œsophageus. It is therefore clear that there is something more powerful at the cricopharyngeal level than in the œsophageal wall. It is not until the hiatus œsophagus is reached that we encounter a

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like rigidity. At this point we have another group of pericœsophageal muscles, the diaphragmatic pinchcock musculature of the diaphragm.

Whatever may be the anatomist's viewpoint, he who does œsophagoscopy without anæsthesia cannot but feel that it is wrong to class the orbicular fibres at the upper end of the œsophagus as simply part of the circular coat of muscles of the œsophagus, on the one hand, or simply part of inferior constrictor on the other.

It is my opinion, based on œsophagoscopic studies, that it is the barrier presented to the advance of the bolus by the unrelaxed cricopharyngeus that is the functional factor that herniates the pharyngeal wall, thus creating the pharyngeal diverticulum. The wall of the hypopharynx and œsophagus is weak everywhere, but is as strong here as elsewhere; and seems better supported in the neck than in the case of the thoracic oesophagus. But the thoracic œsophagus does not have the obstruction ahead except
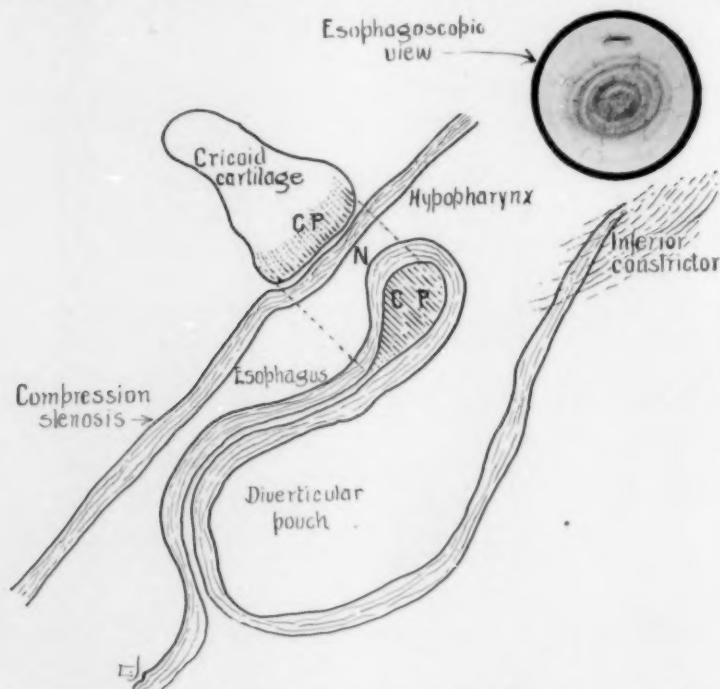
FIG. 1.—Schema showing the authors' theory of the *functional* factor in the etiology of pulsion diverticulum. The chief functional etiologic factor is the cricopharyngeus muscle (CP) which normally pulls the cricoid cartilage back against the spine maintaining, in health, a tonic closure of the œsophageal mouth (N). The abnormal etiologic factor arises when the cricopharyngeus fails to relax at the approach of the bolus propelled by the powerful contraction of the inferior constrictor, the powerful squeezing muscle. The *structural* factors demonstrated by Mosher are doubtless of equal or greater importance. This drawing also illustrates the secondary compression stenosis, which, along with the enlargement of the pouch and the increased deglutitory pressure, constitutes the vicious circle on which inevitable increase of dysphagia and discomfort depend. In the œsophagoscopic view the cricopharyngeus muscle, CP, is concealed under the mucosa between the diverticular pouch shown below and the slit-like orifice of the subdiverticular œsophagus shown at the top of the circular field of vision.

in cases of so-called cardiospasm, which is due, in many cases at least, to failure of the diaphragmatic pinchcock muscles to relax, in other words, a pathologic mechanism analogous to that present in pharyngeal diverticulum. Summing up the matter, the essential mechanism is not so much the propulsion of the oblique fibres of the inferior constrictor, as the failure in the coördinate obliteration of the normal obstruction ahead.

In a number of our cases of pulsion diverticulum organic stricture in the

orifice has required œsophagoscopic dilatation. Because of the coördinate failure of the cricopharyngeal pinchcock to open seeming an important factor in etiology, it has seemed to us advisable to stretch the cricopharyngeal constriction gently even when not organically strictured, to lessen the tendency to recurrence. This cannot be done with the same vigor as in the case of the anal sphincter at a hemorrhoidal operation. The passage of the largest sized œsophagoscope is usually sufficient, and is safe in careful experienced hands. This has, we believe, been an important factor in the prevention of
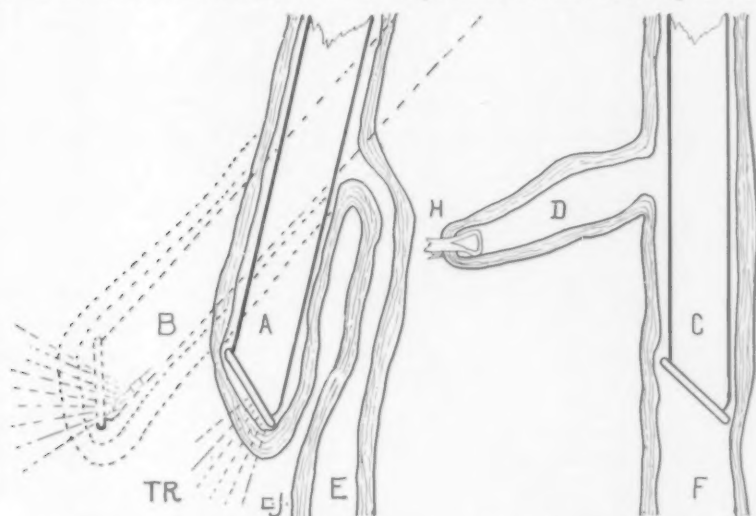
FIG. :—Schematic representation of œsophagoscopic aid in the excision of a diverticulum. At A the œsophagoscope is represented in the bottom of the pouch after the surgeon has cut down to where he can feel the œsophagoscope. Transillumination (TR) from the œsophagoscopic lamp greatly assists the surgeon in identification of the sac. Then the œsophagoscopist causes the pouch to protrude as shown by the dotted line at B. After the surgeon has dissected the sac entirely loose from its surroundings, he makes traction upon the sac as shown at H and the œsophagoscope is inserted down the lumen of the œsophagus as shown at C. The œsophagoscope now occupies the lumen which the patient will need for swallowing. It only remains for the surgeon to remove the redundancy, without risk of removing any of the normal wall.

post-operative leakage and in prevention of recurrence of pulsion diverticulum, in our cases.

The mechanism of so-called traction diverticulum is essentially different (Fig. 4). The absence of anything corresponding to the cricopharyngeal pinchcock accounts for the well-known clinical fact that traction diverticula are usually unaccompanied by dysphagia.

ŒSOPHAGEAL DIVERTICULA FROM THE SURGEON'S VIEWPOINT

BY THOMAS A. SHALLOW

Diverticula of the œsophagus are not increasing in frequency but the diagnosis is now made much more certainly than formerly. Diverticula used to be missed, they are now discovered. The improved methods of diagnosis, the œsophagoscope, the fluoroscope and röntgenograms, enable us to recognize this operable form of dysphagia and to distinguish it with certainty from other often inoperable forms. Hence diverticula are now more frequently recognized.

In contrast with the certainty of present-day diagnosis, the older literature shows many cases in which the cause of the dysphagia was never recognized during life and in which a post-mortem examination disclosed a pulsion diverticulum.

Much has been said of the etiology and of the morphological characteristics of œsophageal diverticula. Two types of diverticulum of the œsophagus are accepted by authors, viz., (a) the pulsion type; (b) the traction type.

We desire to point in this paper to several unusual forms of diverticula—(1) the congenital form; (2) the double diverticula; and (3) a form in which malignancy is a contributing cause. We will question the accepted view—that diverticula do not occur before middle life and will present a case in which symptoms of a diverticulum existed in a boy at the age of twelve years.

Congenital Diverticula.—In presenting a case which we believe to be one of congenital diverticulum, we realize that William Boyd[2] states that congenital diverticula do not exist. If this view of Boyd's is correct, then, of course, we are wrong, and we must try to determine—with what we are dealing? Is it a traction diverticulum or is it the hypertrophied remains of one of the branchial clefts? With these thoughts in mind we present the case.

FIG. 3.—Schematic illustration of post-operative conditions illustrating the advisability of œsophagoscopic stretching of the cricopharyngeus muscle, CP. The inferior constrictor, the powerful squeezing muscle, propels the bolus in the direction of the subdiverticula, passage, (N, Fig. 2), surrounded by the cricopharyngeus muscle, CP, to reach the œsophagus. If the cricopharyngeus fails to open promptly, widely and coördinately, enormous pressure is put upon the stump of the removed diverticulum, causing in some cases leakage before, and recurrence after healing. Overactivity of the cricopharyngeus is obviated by careful œsophagoscopic stretching at operation. In addition to the incoördination referred to, the structural factors demonstrated by Mosher contribute to the primary etiology. This illustration shows the stump before invagination.

CASE I.—J. B., male, age eight years, was admitted to the surgical service of Prof. J. Chalmers DaCosta, with fever, flatness of the right side of chest and all the physical signs of empyema. Following a rib resection for the evacuation of pus, which was present, he discharged particles of food through the external chest wound. Because of his very poor condition and the necessity of a gastrostomy, which was done, œsophagoscopy was delayed until the symptoms of sepsis subsided. The patient died fourteen days

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after the operation without diagnostic œsophagoscopy and the clinical diagnosis of perforation of the œsophagus was made. Post-mortem examination by Dr. Baxter L. Crawford disclosed a narrow tube springing from the posterolateral wall of the œsophagus, 11 cm. from the laryngeal opening, extending downward and backward. The tube was 2½ cm. long, 4 cm. in diameter, and of equal calibre throughout its entire length. The course of the tube was downward and outward. The distal end opened into the chest cavity through the dome of the pleura; thus explaining the cause of the empyema and the reason for the food passing through the thoracotomy wound. Microscopic examination of this tube showed its wall to be in three distinct layers, corresponding structurally to those of the œsophagus and hence our decision that the tube was a true diverticulum. (Fig. 5.) Sections made at various levels of the tube showed the same

distinct layer arrangement of mucosa, submucosa and muscular fibres. This fact, in conjunction with the almost right angle connection of the tube with the œsophagus and the absence of any inflammatory changes in the œsophageal wall or near the junction of the tube to the œsophagus, lead us to discard the diagnosis of traction diverticulum. To account for this unusual condition we, therefore, should consider the possibility of a pharyngeal branchial fistula as a causative factor.

Maylard [3] states that a congenital diverticulum may be caused by the persistence of one of the branchial clefts. We are told by Von Bergmann [4] that a persistent branchial cleft, with the resultant cyst or fistula, involves the second cleft only, the course of the cyst or fistula being between the internal and the external carotid arteries. The internal landmark of a

FIG. 4.—Schematic illustration of the classic type of traction diverticulum due, or supposed to be due to traction of a scar external to the œsophageal wall, at A. It has been supposed that the reason such diverticula are symptomless is that the lower rim of the pouch, B, is as low as the bottom of the sac or at least lower than the upper rim of the entrance to the pouch, E. In the authors' opinion, however, the true reason lies in the anatomical fact of the absence of an orbicular muscle at D to act analogously to the cricopharyngeus which in the authors' opinion is a powerful factor in the etiology of pulsion diverticula. (Compare with the cricopharyngeal pinchcock, CP, Fig. 1.)

second branchial cleft is in the pharynx behind the tonsil, at which point the fistula may open into the pharynx. If an external fistula is present the cutaneous opening is along the anterior edge of the sterno-mastoid muscle. Thompson [5] states that internal openings due to perforation of the third or fourth cleft membranes are infrequently seen, but when present they open lower down in the sinus pyriformis. He further states that the course of the tract of the third cleft is below the internal carotid artery and above the superior laryngeal nerve. The same author says that theoretically a fourth cleft should pass downward; on the right side it should hook around the subclavian artery and on the left side it should hook around the aorta. Thompson remarks in his article that he is not familiar with any observation showing a fistulous tract passing around the subclavian artery or the aorta. Let us compare the morphology of the wall of a fistula of the second branchial
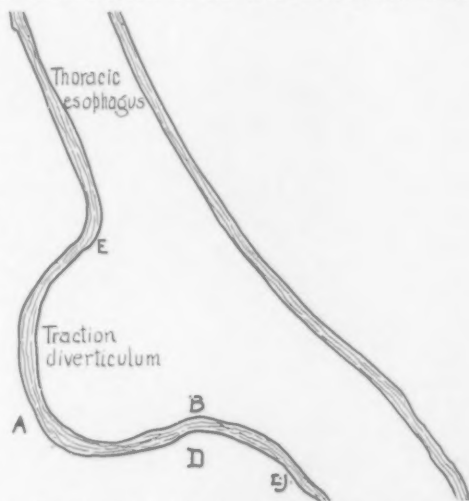
cleft as found in the case of Seelaus[6] with that of the supposed congenital diverticulum which we report.

"Specimen consists of a small tubular structure measuring 6 cm. in length. The average diameter is 0.75 cm. At one extremity there is a small pin-point opening and on cross-section there is a lumen throughout the length of the specimen with average diameter of 0.5 cm. The lumen, however, is much smaller in some places than in others. Formalin fixation.

"*Histology.*—On cross-section the structure is found to possess a definite lumen which is lined with stratified squamous epithelium and just beneath this epithelial lining in places there are collections of lymphoid tissue and also a few mucus glands are observed. There is a definite fibrous tissue coat forming the main portion of the wall of the fistula, but no muscle is observed except fragments of striated muscle attached externally. The mucosa is inflamed and ulcerated and in places the lumen is filled with necrotic material and leucocytes, many of which are polymorphonuclears. Sections were taken from various portions of the structure and the epithelial lining is constant.

"*Diagnosis.*—Squamous epithelial lined fistula.

"Microscopic examination of cross-section of congenital diverticulum showed same to be lined with stratified squamous epithelium and a thickened submucosa. Muscular coat is well developed." (Fig. 5.)

FIG. 5.—Microphotograph of cross-section of congenital diverticulum existing in a boy eight years of age, showing the distinct mucous coat and part of the muscular coats. The entire specimen is of the same calibre throughout.

From what has been said by Thompson and Von Bergmann, the depression of the second cleft is behind the tonsil. This point is far above the site of the origin of the congenital diverticulum described in this paper. It necessarily follows that the tube we describe as a congenital diverticulum does not spring from the second cleft. There are no recorded cases of fistula of the third or fourth clefts to compare with the structure found in our case. It is also noted that the opening into the œsophagus in our case is far below the point where Thompson states the third and fourth clefts should open. We, therefore, assume that we are dealing with a true congenital diverticulum.

Juvenile Diverticula.—The common view that diverticulum of the œsophagus does not exist before the fortieth year is shaken by the following case. Dr. D. W., male, age fifty-four. Doctor W. stated that when a youngster on a farm he amused the other boys by regurgitating grapes which he had swallowed a number of hours before. During the period of forty years from the time he came to operation, he had the classical symptoms of diverticulum of the œsophagus, with the exception that he did

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not begin to lose weight until very recently. He accounted for this by the fact that after filling the sac with food he was able to swallow without difficulty. X-ray examination by Doctor Manges disclosed an œsophageal diverticulum at the pharyngo-œsophageal level. The sac is a little to the right in the median line and almost entirely on the posterior wall. Figure 6 will show the size and location of the sac.

This unusual history given by a practicing physician from one of the large cities of New York State leads us to believe that diverticulum of
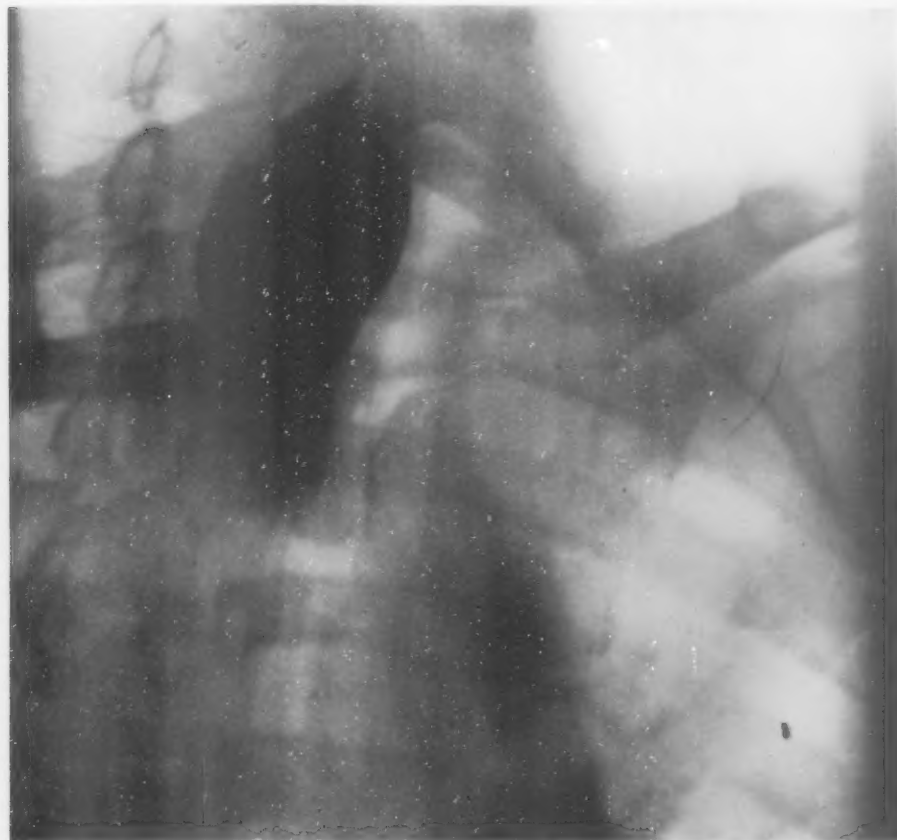
Fig. 6.—*Juvenile diverticulum.* Present symptomatically for forty years prior to operation. The symptoms were first noticed when patient was twelve years old by his trick of voluntarily regurgitating grapes which he had eaten a number of hours before.

the œsophagus may exist in some cases long before the fortieth year, and because of the trivial symptoms manifested remain undiagnosed for years. Therefore, in order to emphasize the possibility of early origin, we have classified this case as a juvenile diverticulum.

Double Diverticula.—Great emphasis has been placed by various writers on diverticulum of the œsophagus on the supposed causative factor. They all agree that there is a congenital weakness at Laimer's triangle. This congenital weakness should be regarded as being at least a part factor in the production of diverticula. That some other factor or factors are concerned

in the production of diverticula is unquestionably true, otherwise multiple diverticula could not form. In the case we are now presenting we show by the X-ray picture a double diverticulum. (Fig. 7.) We present a second plate to show the second diverticulum existing after the removal of the first. (Fig. 8.)

P. B., male, age sixty-five. The chief complaints are difficulty in swallowing and the loss of sixty pounds in weight. The present illness dates back twenty years, at
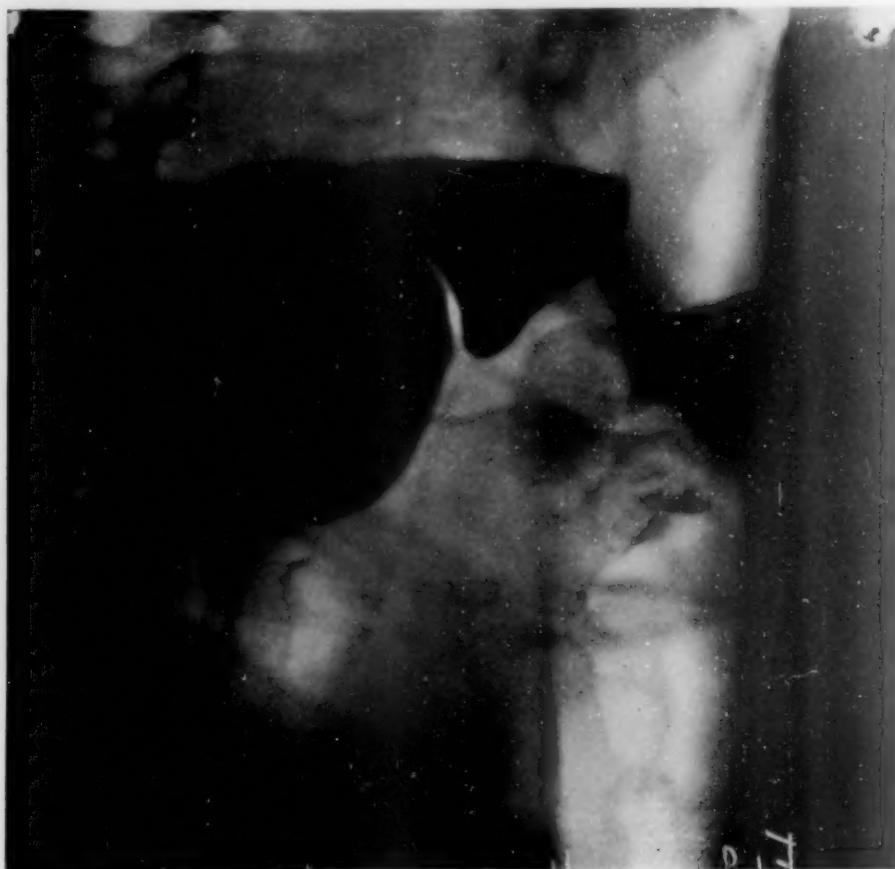
FIG. 7.—*Double diverticulum.* Showing one pouch filled and the other pouch filling. Prior to operation this patient was able to return two full glasses of water. It will be noticed in this picture that one pouch presents on the left side and the other pouch on the right side.

which time the patient first noticed that he was able to regurgitate food that he had eaten some hours before. He fixed this date absolutely in his mind because he moved from one part of Pennsylvania to another at this period, which he states was twenty years ago. During the past three years he noticed increasing difficulty in swallowing food and a peculiar noise in his throat when eating so that he was compelled to eat alone. He was treated by many physicians for various conditions. A diagnosis of diverticulum was made. X-ray examination by Doctor Manges shows: "Quite a large diverticulum of the œsophagus which has two distinct pouches, the smaller one and the higher

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extends toward the left and the larger one is more nearly in the median line, presenting toward the right posteriorly."

Operation.—Preliminary gastrostomy was performed under local anæsthesia. After an interval of ten days he was operated upon by the combined method. The diverticulum presenting on the left side was exposed and found to extend down to the suprasternal notch. The capacity of this sac was six ounces. The œsophagoscopic examination by Doctor Jackson during the course of this operation disclosed two openings, one above the other, with no communication between the sacs. In other words, it was not a
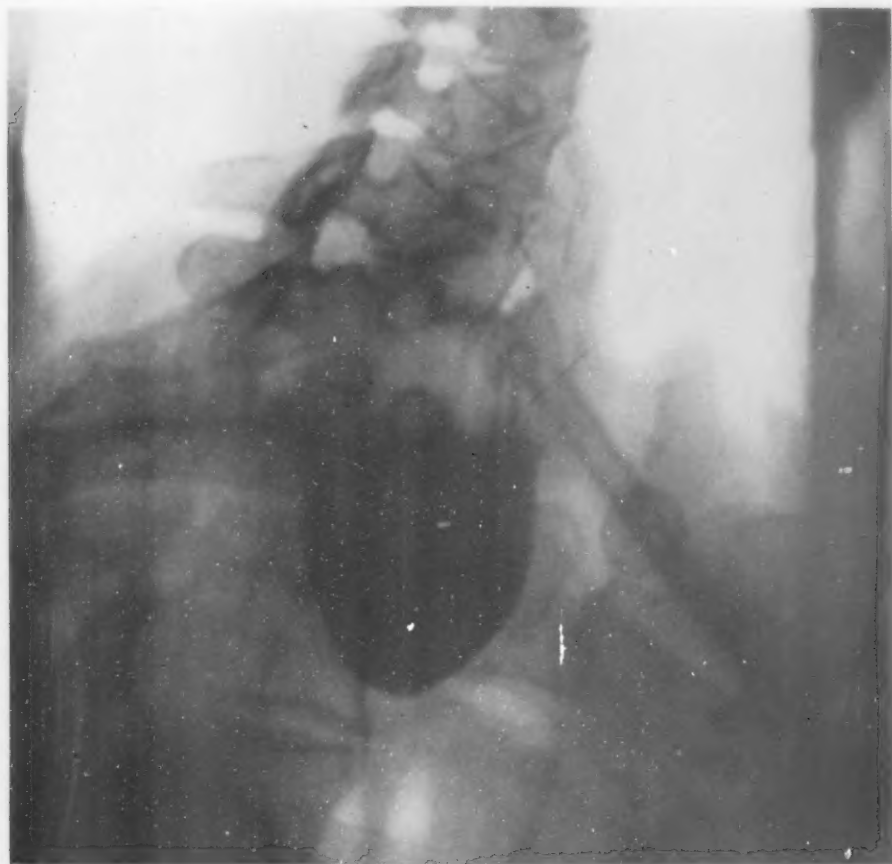
FIG. 8.—*Double diverticulum.* Showing the left pouch remaining after the removal of the right pouch, as shown to exist in Fig. 7.

multilocular single diverticulum but each sac sprang from an independent site. Figure 8 shows the remaining diverticulum after removal of the first. Ten days following the removal of the first diverticulum the right side was operated upon by the combined method. The fundus of the diverticulum was adherent to the dome of the pleura and to the subclavian vein. The neck of the sac seemed to expand as it approached the œsophagus. A glance at the first plate, showing the presence of both diverticula, will make evident the broad barium surface present in the picture. The sac was amputated close to the œsophagus. The procedure was a one-stage operation.

The patient reacted from the operation, but to our chagrin a number of months later he returned with a history that he was again storing up food and had developed the symptoms of a diverticulum. The X-ray plate disclosed that he had a

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diverticulum on the right side which extended into the chest cavity, and was probably a recurrence and not a sac missed at the former operation. He was again operated on by the combined method, and it was found by Doctor Jackson that the opening was toward the right, probably in the region of the original right-sided diverticulum. In exposing the fundus of the diverticulum in the chest cavity and in order to protect the innominate and subclavian vessels, it was necessary to use in the root of the neck, an abdominal retractor with a two and one-half inch blade. It was found that the fundus of the sac was adherent to the arch of the aorta from which structure it had to be cut by long-handled gynæcological scissors. The parts were illuminated by the light of an additional bronchoscope passed along the retractors in the root of the neck, thus direct vision could be employed. The sac was amputated at its junction with the œsophagus. It was a one-stage operation. The mediastinum was protected by iodoform gauze and a small cello-silk drain was introduced.

There was much more reaction from this operation than from any of his previous ones. He was fed through a Rehfuss tube by way of the nose for eighteen days; at the expiration of which time the tube was removed. The patient is now swallowing without any

Fig. 9.—*Malignant diverticulum.* Showing the existence of a diverticulum which showed malignancy. A distinct pouch with irregularities in its base. It will be observed that this pouch is much lower than the pulsion diverticulum. Pouch with the œsophagus extirpated.

difficulty, six months after the operation, and we hope that a permanent cure has been obtained.

Malignancy as a Cause of Traction Diverticulum.—To consider the two previous cases, one of which existed for forty years, and the other for twenty years, is to wonder why malignancy does not occur in diverticula more frequently than has been reported. In presenting this case we do not wish to give the impression that we are dealing with a pulsion diverticulum which had undergone malignant changes; but to show that if the sac preceded malignant growth that it was a traction diverticulum and also to point out the uncertainty of even X-ray diagnosis and the necessity for œsophagoscopy.

The case is presented in this series to emphasize the absolute necessity of œsophagoscopic study previous to any operation of this nature on the œsophagus. The results of the œsophagoscopic examination were absolutely conclusive. The specimen removed for study disclosed a squamous-cell epithelioma.

J. T., male, age sixty. The chief complaints are difficulty in swallowing solid food, loss of weight, intermittent pains across the sternum and slight hoarseness. The present illness dates back only eight weeks at which time the patient first noticed difficulty in swallowing solid food. With the onset of this condition he began to regurgitate food. The X-ray examination was made by Doctor Manges. "There is an organic lesion on the upper end of the œsophagus at the level of the suprasternal notch, a little lower than the usual site of a diverticulum, but there is apparently a diverticulum present. The lower border is irregular. I suspect there are adhesions. We believe it is a diverticulum, but we are unable to exclude a possible infiltrating growth." (Fig. 9.)

The results of the œsophagoscopic examination and the laboratory report of

FIG. 10.—*Traction diverticulnm.* Showing the existence of a cervical traction diverticulum which was not extirpated but anchored to the deep cervical fascia.

the specimen influenced Doctor Jackson to advise a preliminary gastrostomy and the removal of the upper part of the œsophagus, including removal of the diverticulum.

Under intratracheal ether anæsthesia the œsophagoscope was introduced so that it passed below the level of the growth. A collar incision was made in the neck, the recurrent laryngeal nerve of the left side was isolated and drawn outward. The left lobe of the thyroid gland was removed and the œsophagus was exposed. At the suprasternal notch the œsophagus was found to be densely adherent to the fascia at the fundus of the diverticulum. I believe it to have been a traction diverticulum; and I believe so because of the dense adhesions surrounding the œsophagus at this point. With the

œsophagoscope in position in the œsophagus, we exposed the normal œsophagus two inches below the suprasternal notch. The œsophagoscope was then withdrawn, the œsophagus was ligated, was severed below the growth nearby, and the distal end was invaginated. The upper portion of the œsophagus was removed to its origin. At this point it was ligated, but it was impossible to get a perfect invagination.

Iodoform gauze was used to protect the mediastinum from any leakage from the upper end of the pharynx. The patient reacted well from the anæsthetic and made an uneventful recovery. It is now a number of months since the operation and as yet he shows no sign of local recurrence of the growth. He has gained in weight and is being fed through the gastrostomy opening.

We believe that the carcinoma caused a traction diverticulum.

Pulsion Diverticula.—Our experience with pulsion diverticula leads us to say that they do not all spring from the one narrow location usually assigned to them. Some are lower than others. We have noticed that they may arise irregularly in an area about one-half inch below the junction of the pharynx and the œsophagus. Von Bergmann calls sacs arising at this low level deep œsophageal diverticula. (Dr. G. Lotheissen in *von Bergmann's System of Practical Surgery.* American edition. Edited by Dr. W. T. Bull.)

The pouch originates on the posterior aspect of the œsophagus and usually advances toward the left or right, usually to the left, and gradually increases in size. With the increase in size the œsophagus may be drawn upon and partially rotated on its longitudinal axis. When rotation arises swallowing becomes more difficult and the diverticulum increases more rapidly in size. May not rotation of the œsophagus account for the variation in the size of the diverticulum in different patients? That the sac does not develop toward the left side of the neck in all cases is exemplified by several of our patients. In these the sac was found on the right side of the neck. This fact is of some importance from a surgical standpoint. The operation should be done on the side of the neck on which the sac presents, because with the rotation of the œsophagus toward the side on which the sac is more pronounced, one is able to obtain a better exposure for repairing the opening in the tube.

Complications of the operation for pulsion diverticulum of the œsophagus are: 1. Insufflation pneumonia; caused by manipulating a partially filled sac, and squeezing out semiputrid contents. Many septic particles are inhaled from large diverticula. 2. Mediastinitis; due either to primary soiling of the wound in manipulating the sac, or to leakage from the site of the amputation of the sac during convalescence. 3. Secondary hemorrhage from one of the thyroid arteries exterior to the thyroid gland or from vessels of the gland itself. 4. Œsophageal fistula may follow an operation or a sac may reform. 5. Recurrence of the diverticulum.

Operation.—We believe the employment of the œsophagoscope as an aid to the surgeon simplifies the operation to such an extent that the use of this instrument is almost indispensable. (Fig. 7.) The œsophagoscope, by transillumination of the sac and by lifting it from its bed, permits the operator

to quickly pick it up. The sac is emptied by aspiration through the œsophago-scope and foreign material, such as foreign bodies (in one case there were pieces of an oyster shell) and retained food and secretions are removed. By this procedure the danger of aspiration pneumonia is practically eliminated. This method of operation is known as the Gaub-Jackson [7] operation. (Fig. 2.)

After the delivery of the sac the œsophagus is examined at intervals by the œsophagoscope in order to detect the presence of any deformity of the gullet below the diverticulum. It is sometimes noticed that there is a con-striction below the diverticular opening. If found, this stenosis must be treated by the surgeon during the suturing of the œsophagus. Finally, in reinforcing the œsophageal walls by sutures, the danger of causing too much narrowing of the œsophagus is prevented by the œsophagoscope being left in position within the lumen of the œsophagus, until suturing has been com-pleted. (Fig. 8.)

The danger of infection during operation is to a great extent eliminated by the thorough emptying of the sac through the œsophagoscope so that when the amputation of the sac is performed there is little danger of contamination. The danger of the development during convalescence of infection from the site of closure of the neck of the diverticulum formerly gave us very great concern, so much so that it was our habit to employ preliminary gastrostomy for feeding during this period. We have abandoned this precaution and feed all of our patients through a Rehfuss tube left in position through the nose and in the stomach during the entire convalescence. This suggestion was made by Dr. F. O. Lewis and Dr. Louis H. Clerf.

In this series of cases we have used in some the one-stage operation and in others the two-stage operation with fixation of the sac. As the result of our experience we believe that the one-stage operation, with the aid of the œsophagoscope and with the use of the Rehfuss tube, is the safest and gives the best results.

Technic of Operation.—Under intratracheal ether anæsthesia the patient is prepared in the usual manner and an incision is made on the side on which the sac presents and along the anterior border of the sterno-mastoid muscle. The cut is to reach from the level of the hyoid bone to one inch above the sternum and is to pass through the skin and deep fascia, exposing the anterior belly of the omo-hyoid muscle. This muscle is then to be divided transversely. In this cut the external jugular vein may be exposed, and if it is, it should be divided and tied. The common carotid artery and the internal jugular vein are now exposed and retracted outward. If the thyroid gland is decidedly enlarged, it is sometimes necessary to ligate and cut the superior thyroid artery. The trachea and the œsophagus will be found to be encased in a common sheath, which is to be incised, exposing the œsophagus in the pos-terior part of the wound and the trachea in the front. The trachea is then retracted toward the midline.

The œsophagoscope is introduced by Doctor Jackson or one of his asso-

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ciates, Dr. Louis H. Clerf or Dr. Gabriel Tucker. The sac is emptied of its contents by aspiration, thereby avoiding squeezing the fluid into the pharynx. The œsophagoscope is then introduced into the bottom of the diverticulum and the sac transilluminated, and the œsophagoscopist rotates the sac into the wound. The sac is grasped with the Babcock clamps and drawn further upward and outward. It will be found at this point that the sac is sometimes covered by a thin layer of muscle. This muscle is separated. The sac is then freed to the junction of the diverticulum with the œsophagus, being careful to free all muscle fibre from its covering. The neck of even the largest diverticulum is seldom one-half an inch in diameter. A neck apparently larger than this usually means incomplete dissection, the genuine neck not having been reached. The sac is then transfixed with a small intestinal needle carrying No. 1 iodized catgut in much the same way as a hernia sac is transfixed, and is severed close to the œsophagus. By this method no leakage occurs during section.

We believe that the mere amputation and ligation of the sac without preliminary transfixion and ligation are not sufficient to cure a diverticulum of the œsophagus. After transfixion, ligation and amputation, we reef the area of gullet around the base of the stump by the use of three sutures of catgut, inserted at intervals, each one picking up the muscular coat of the œsophagus. These stitches cause inversion. Some surgeons use a purse-string stitch, but if the opening is large it is impossible to cover the stump by this method. Simple reef stitches at several points of the circle invaginate the stump easily and firmly. By leaving the ends of the reef stitches long enough the suture line can be reinforced by the ends carried across and tied to the opposite ends. This narrows the œsophagus to a certain extent, and if the œsophagoscope was not *in situ* during the suturing the danger of narrowing would be decided. The musculature upon the sac which was separated in freeing that structure is then sutured with No. 1 gut over the embedded stump not so much to secure strength, as to give an additional protection against leakage during the first few days. The incision in the neck is closed in layers, no drainage being used except a small piece of cello-silk placed beneath the deep fascia.

We do not use tube drainage or gauze drainage. A rubber tube may make pressure on the thyroid gland and be responsible for secondary hemorrhage. This is especially apt to be the case if the patient is restless or has severe spells of coughing. A number of the cases we operated upon for œsophageal diverticulum had chronic bronchitis before the operation and during the post-operative period coughed up a considerable quantity of muco-purulent matter. One of our patients developed secondary hemorrhage from this cause. We believe that gauze tends to produce leaking and a fistula in the same way as it does after an operation for vesico-vaginal fistula or suturing the ureter.

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CASE REPORTS

CASE I.—Male, J. B., age eight years. This case was discussed in the general text of this paper as a congenital diverticulum.

CASE II.—Male, D. W., age fifty-four years. This case was discussed in the general text under juvenile diverticulum.

CASE III.—Male, P. B., age sixty-five years. This case was discussed in the general text of this paper as a multiple diverticulum.

CASE IV.—Male, J. T., age sixty. This case was discussed in the general text of this paper as a malignant traction diverticulum.

CASE V.—Male, H. E., age sixty-eight years. Chief complaint, difficulty in swallowing any dry solid food. This condition has existed for the past year and within the past few months has become more pronounced. He is conscious of gurgling noises in the throat particularly after eating. There is nothing in the family or personal history that could bear upon his case except that he had typhoid fever fourteen years ago. He has lost considerable weight, the exact amount he is unable to determine. Œsophagoscopic and X-ray examinations were made by Doctor Jackson and Doctor Manges. Doctor Manges says there is a small diverticulum of the œsophagus at the level of the seventh cervical vertebra on the posterior wall in the median line.

Operation.—No preliminary gastrostomy was done but the combined œsophageal operation by Doctor Jackson and Doctor Shallow, disclosed a small sac. Because of the patient's general condition it was deemed advisable not to amputate the sac at the preliminary operation but to leave it for a secondary operation. The sac was, therefore, freed and surrounded by gauze. On the eighth day the sac sloughed and left a discharging sinus. This fistula discharged for a number of weeks but finally closed without any secondary operative intervention.

Post-operative Progress.—The patient remained in the hospital three weeks after the operation. The fistulous tract had not entirely healed on discharge but was healing rapidly. He was seen the following month and the neck was entirely healed. There has been no further trouble with this diverticulum.

CASE VI.—Male, F. D. P., age fifty-six years. Chief complaints are, lodgment of food in the neck and noisy deglutition. The first intimation that the patient had as to any obstruction in his œsophagus was two years ago when he spat out a watermelon seed he had eaten a number of hours before. X-ray examination by Doctor Manges discloses a diverticulum of the œsophagus, perhaps a little to the left of the median line; it has rather a narrow opening and the sac holds about one-half an ounce. Œsophagoscopic examination by Doctor Jackson confirms the X-ray diagnosis as to the size and location. Operation. No preliminary gastrostomy. The combined Gaub-Jackson operation by Doctor Clerf and Doctor Shallow. Primary amputation of the sac, reinforcement of the œsophagus. Closure except for small piece of cello-silk beneath the deep fascia.

Post-operative Treatment.—The patient was fed through the nose by means of a Rehfuss tube, passed into the stomach and retained for eighteen days. Stitches and cello-silk removed on the tenth day. Primary healing of the wound. X-ray examination on the sixteenth day by Doctor Manges disclosed no evidence of diverticulum, but a slight narrowing of the œsophagus at the site of the original opening of the sac.

CASE VII.—Female, Mrs. E. D., age sixty-two years. Chief complaint, regurgitation of particles of food several hours after eating. Clicking sensation on swallowing. Trouble has existed for past five years. She has been treated by numerous physicians for "nervousness." She has lost about twenty pounds. X-ray examination by Doctor Manges disclosed a rather large diverticulum of the œsophagus a little higher than the average; apparently just a little below the larynx. Œsophagoscopic examination by Doctor Jackson disclosed an opening about in the site shown by the X-ray. Operation.

Combined Gaub-Jackson two-stage operation. The sac was found to be large and at outer surface adherent to the right side of the neck. The outer surface was composed of muscle which had much the appearance of the constrictors of the pharynx. Owing to the large size it was deemed advisable to do a two-stage operation. The sac was surrounded by gauze (iodoform) and the wound was left open. On the tenth day secondary operation was done with closure of the opening, which was on the lateral wall of the pharynx.

Post-operative Treatment.—Patient was fed through a Rehfuss tube as was Case VI for eighteen days after the completion of the second operation. X-ray examination following the second operation did not disclose any evidence that a diverticulum had ever existed.

Case VIII.—Male, L. R., age forty-seven years. Chief complaints, difficulty in swallowing solid food, regurgitation of food, and noisy deglutition. X-ray examination disclosed a moderate sized diverticulum of the œsophagus at the usual location. The sac is very little more than one inch in diameter. Operation. Combined Gaub-Jackson method by Doctor Jackson and Doctor Shallow. The sac was exposed and found to spring from the posterior wall of the œsophagus. The sac was amputated, the wound in the œsophagus was ligated and sutured as directed and the incision was closed except for a cello-silk drain.

Post-operative Treatment.—Drain and stitches were removed on the tenth day. During the convalescence the patient was fed through a Rehfuss tube for sixteen days. X-ray examination following the operation—"there is no indication that a diverticulum of the œsophagus ever existed. The lumen is slightly narrowed at the site of the former diverticulum. The outline is very smooth." Patient discharged cured twenty-four days after operation.

Case IX.—Male, J. C. L., age fifty-nine years. Chief complaints are difficulty in swallowing food, solid and liquid, regurgitation of liquids and particles of food between meals. He has lost much weight. The first symptoms were noticed five years ago. He consulted a number of physicians and various diagnoses were made. He was unable to work, was practically confined to bed just previous to his admission to the hospital. X-ray and œsophagoscopic examinations disclosed a well-developed diverticulum springing from the usual site. Operation. Preliminary gastrostomy and the combined Gaub-Jackson operation were performed at the same seance. The sac was exposed and found to be densely adherent. The sac was amputated at the œsophagus. The œsophageal wall was reinforced.

Post-operative Treatment.—Patient was fed through the gastrostomy tube. Stitches were removed from the neck on the tenth day. There was a slight discharge from the deep tissues of the neck. This persisted for five days after which the wound healed rapidly. One month after the operation the gastrostomy tube was removed and the gastric fistula was permitted to heal. The neck wound healed entirely eighteen days after the operation. X-ray examination on the twenty-second day disclosed no evidence that an œsophageal diverticulum had ever existed. Patient was discharged in good condition and has since gained thirty-five pounds in weight.

Case X.—Male, A. A. N., age fifty-six years. Chief complaints, dysphagia for solid food, slight hoarseness, loss of ten pounds in weight. Present illness dates back one and a half years, at which time while eating toast he had a severe choking attack, following which he developed fever, difficulty in swallowing and a severe pain in the neck. Since this attack he has been unable to swallow solid food. X-ray examination disclosed a small diverticulum, the sac reaching to a little above the upper border of the sternum. The diverticulum is irregular in its lateral borders and presents somewhat to the right of the median line. Owing to the difficulty in swallowing we were unable to get information as to the size of the opening. The œsophagus below this point is

entirely normal. This case is shown in Fig. 6 as a traction diverticulum. Preliminary gastrostomy and the combined Gaub-Jackson operation performed at the same seance. There were extensive periœsophageal adhesions. The pouch was found to be adherent to the under surface of the thyroid gland. The œsophagus was drawn into irregular folds around the diverticulum. The sac was dissected from the dense adhesions and the irregularity of the œsophagus unfolded, the sac was fixed to the deep cervical fascia so that the fundus presented at a higher level than the opening.

Post-operative Treatment.—The patient's convalescence was uninterrupted. The gastrostomy tube was removed three weeks after the operation. The cervical wound healed by first intention. X-ray examination, following the operation, by Doctor Manges: " There is a small quantity of barium retained in a little pouch at the level of the first dorsal vertebra. It has a wide opening and doesn't interfere with swallowing." On the patient's discharge from the hospital he was able to eat regular house diet.

Case XI.—Male, J. G. R., age sixty-nine years. Chief complaints, lodgment of food in the œsophagus, gurgling noise on deglutition, regurgitation of food. Loss of considerable weight. Present trouble dates back four years. X-ray examination and œsophagoscopic examinations by Doctor Manges and Doctor Jackson disclosed a diverticulum at the usual level, slightly larger than the average sac. Preliminary gastrostomy was performed, with the combined Gaub-Jackson operation for diverticulum of the œsophagus by Doctor Clerf and Doctor Shallow. Primary amputation of the sac with reinforcement of the œsophagus was done in one stage. The wound was closed except for a small drain of cello-silk at the lower angle.

Post-operative Treatment.—Ten days after the operation the stitches and cello-silk were removed. The wound healed by primary intention except for the small opening left after the drain had been removed. Twenty-one days after the operation the gastrostomy tube was removed and the patient was allowed to eat regular house diet. Twenty-four days after operation X-ray examination disclosed no evidence of a diverticulum. There is a slight narrowing of the œsophagus at the site of the operation.

Case XII.—Male, A. J. B., age sixty-five. Chief complaints are huskiness of voice, occasional regurgitation of particles of food, gurgling noise on swallowing and loss of weight. X-ray and œsophagoscopic examinations made by Doctor Manges and Doctor Jackson disclosed a diverticulum of the œsophagus a little below the cricoid cartilage. The sac projects a little more to the right than usual. Operation. Combined Gaub-Jackson operation for diverticulum of the œsophagus by Doctor Jackson and Doctor Shallow. The sac was removed. The wound in the œsophagus was reinforced after suturing. It was a one-stage operation.

Post-operative Treatment.—The patient was fed through a Rehfuss tube during his convalescence which lasted twenty-two days. On the tenth day the stitches and cello-silk drain were removed. Twenty-one days after operation X-ray examination by Doctor Manges showed that there was no evidence that a diverticulum had ever existed. · Patient discharged able to eat house diet.

Case XIII.—R. B. H., age fifty-seven years. Chief complaint is slight regurgitation of small particles of food after meals with gurgling noise in neck. Present illness dates back four years. He has not lost any weight. Bronchoscopic examination by Doctor Jackson disclosed a small diverticulum springing from the usual site. Operation under combined Gaub-Jackson method. The sac was found to be small and the neck of it was narrow. The neck of the sac was twisted and the fundus was sutured to the deep cervical fascia and the incision closed.

Post-operative Treatment.—No Rehfuss tube, because the sac was not amputated. Liquid food was given by mouth on the second day. Solid food was given on the eighth day. Uneventful convalescence.

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CONCLUSIONS

1. The most important *functional* factor in the etiology of pulsion diverticulum is the incoördination of the cricopharyngeal pinchcock, resulting in a failure to open of the tonically closed upper end of the œsophagus.

2. The use of the œsophagoscope while the surgeon is doing his work (Gaub-Jackson operation) is the operation of choice for the following reasons: (*a*) Aspiration pneumonia is practically eliminated. (*b*) The easy access to the sac by the use of the œsophagoscope distinctly limits the dissection and hence lessens the probability of mediastinitis. (*c*) By transillumination and protrusion of the sac on the œsophagoscope the structure is quickly identified and its fundus found. (*d*) The time of operation is shortened fully one-half.

3. The reef stitches by slightly narrowing the œsophagus move the point of contact of the bolus of food to a higher level; so that when the food is passing over the old site of the diverticulum, it does so with a greater velocity than normal and the pulsion pressure is less. This phenomenon is demonstrated by fluoroscope examination following healing.

4. The reef stitches reinforce the weak triangular area over the buried stump. Without such reinforcement a potential factor in recurrence of the diverticulum remains.

5. The one-stage operation offers the best possibility for permanent repair, because in a two-stage operation the repair is made in much inflammatory tissue. The two-stage operation is somewhat safer but far less apt to effect a permanent cure.

6. Diverticula do not all spring from the same level. This is exemplified by Case III, the double diverticula. Diverticula may exist at birth, be present in youth and persist for years undiagnosed.

7. Fistula following operation is more frequent after the two-stage than the one-stage method.

8. For post-operative feeding the Rehfuss tube is passed through the nose and into the stomach and is retained for many days in order to afford rest to the œsophagus and to prevent leakage. This method is superior to feeding by way of a gastrostomy. In Case XIII, no gastrostomy was made and the Rehfuss tube was not used.

9. Intratracheal ether insufflation is invaluable in the operation for œsophageal diverticulum. We use no other method of anæsthesia in these cases at the Jefferson Hospital.

10. There were no fatalities in this series of cases.

11. In our series of thirteen cases there was one female. This is in accordance with the accepted opinion that diverticula are much more common in males than females.

12. The oldest patient was sixty-nine years of age. The youngest patient to manifest symptoms of diverticula at the age of thirteen was fifty-four when he came to operation.

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13. The average age of patients was between fifty-five and sixty-five years of age.

NOTE.—Since presenting this paper we have had two additional patients, one of whom made an uneventful recovery—the other patient died on the third day of a massive collapse of both lungs.

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THE ODONTOID OSSICLE OF THE SECOND CERVICAL VERTEBRA

By T. Wingate Todd, F.R.C.S., Eng.

and

Joseph D'Errico, Jr., A.B.

of Cleveland, Ohio.

from the anatomical laboratory of the western reserve university

Introduction.—Frequency of separate ossicle. The problem of the third condyle. Size of the ossicle. Relation to other anomalies. Origin: mamma-

Fig. 1.—Separation of odontoid in W. R. U., skeleton No. 195, male, White, fifty years. The separate ossicle itself is lost. Note the double facet on the atlas.

lian evidence. Life history in man. Evidence of fracture. The single quasi-pathological anomaly. Summary. References.

Variations in the odontoid are by no means unknown. It is true that R. H. Hunter figures a specimen which he regards as unique,[2] but the subject is fully treated by Le Double.[4] Apart from the centres for the body proper of the epistropheus, there is a double centre for the odontoid base and a single

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centre for the odontoid tip. According to Le Double, it was Bevan who first published a case of separation of the odontoid process. This was in a woman of forty years, and the separated piece was united to the border of the foramen magnum.[1]

The present work was undertaken, therefore, primarily to study the anomaly quantitatively.

Frequency of Separate Odontoid.—We have examined, in all, more than

Fig. 2.—W. R. U. No. 337, male, White, thirty-one years. The separate ossicle is fused with the atlas.

a thousand skeletons for this anomaly and have found it three times only. Actually, on the day on which the census of skeletons was taken, there were 969 available. It must be understood that in dealing with large populations like this, the total number fluctuates quite considerably owing to various causes into which it is unnecessary to enter. Realizing, however, that, all told, some 1050 skeletons of known individuals have passed under survey, we can be assured that the anomaly occurs about three times per thousand in a heterogeneous population unselected in family strains. These are quite important points; they, and others like them, must be taken into consideration in stating any anatomical frequency.

The three specimens are all from male Whites; they are the following: No. 195, age 50; No. 337, age 31; No. 1021, age 81 (Figs. 1, 2, 3).

Skeleton census April 6, 1925. Male, White, 629; female, White, 77; male, Negro, 209; female, Negro, 52; other races, 2; total, 969.

From the foregoing it will be seen that the anomaly occurred three times in 600 male White skeletons. It is quite possible, on this frequency, that none would be found among the smaller numbers of the other groups. Consequently, it is perfectly justifiable to argue that separation of the odontoid occurs once in two hundred individuals. The truth certainly lies between this figure and that given in the first paragraph.

The occurrence among male Whites alone is probably coincidence, for the other numbers are not large enough to justify any inference. But we have found certain anomalies which seem to cling to one sex or stock. Fusion of wrist or tarsal bones, of a congenital nature, is very much more frequent in the Negro, whereas separation of the scaphoid into two appears more characteristic of the White. It would require much further information, however, to justify any dogmatic statement.

FIG. 3.—W. R. U. No. 1021, male, White, eighty-one years. Note the arthritic change present in this specimen.

All three present examples are alike in that it is the tip only of the peg which is missing. True, the basal part varies in height, but, as will be shown later, this is really due to the range of variation in the volume of peg formed from the apical centre. In No. 195 the separated portion is lost, but in the others it is fused with the atlas. As a rule, there is a single facet on the

atlas for articulation with the odontoid, but in No. 195 the facet is double, the odontoid articulating only with the upper. The senile specimen, No. 1021, shows that the joint between the mass of the axis and the odontoid is subject to the same quite typical arthritic changes as are characteristic of other senile joints.

We find that the odontoid varies greatly in length. In extreme cases it articulates with the cranial base (Fig. 4).

The Problem of the Third Condyle.—Having mentioned the third condyle, it is appropriate to note that this structure is quite composite in nature. Its position varies slightly in relation to the margin of the foramen magnum, the variation in position being dependent upon the special character of the condyle in that particular specimen. Four forms occur:

1. An articular process for the axis, *e.g.*, No. 668. (Fig. 4.)

2. An ossification of the ligamentum apicis.

3. An articular process for the atlas, *e.g.*, No. 556.

Fig. 4a.—W. R. U. No. 668, female, Negro, thirty-seven years. An example of a long odontoid articulating with the margin of the foramen magnum. The cranial facet is apparent at the tip of the process.

4. A non-articular process for attachment of the occipito-atlantal ligament, No. 246. (Fig. 5.)

The relative positions of the several processes which are covered by the term third condyle are well known on the accompanying radiogram (Fig. 5). Here, also, incomplete ossification gives an hour-glass appearance to the form of the odontoid process. We do not support in any way the theory sometimes put forward that the third condyle represents a persistent median occipital condyle found in reptiles and birds.

For a complete and elaborate account of the third condyle Bolk's work

should be consulted.[7] With this account we find ourselves in entire agreement, except that we would add form 4 mentioned above, a type not specially described by Bolk and yet, in our experience, not uncommon. In the article to which reference is made Bolk suggests that the apical centre is really an ossification of the chorda. We have not convincing evidence of this view and prefer to leave it unsettled: it is not of importance in the present research.

Size of the Ossicle.—Nos. 195, 337, 1021, illustrate in negative fashion the variability in size of the ossicle, that is to say the single apical centre of ossification. Direct evidence is illustrated in the young bones. (Figs. 9, 10, 11.) No. 1089 has a very small ossicle forming no more than the extreme tip of the process. No. 624 has a much larger one which accounts for the entire distal half of the odontoid. Intermediate in size between these two is No. 0.222.
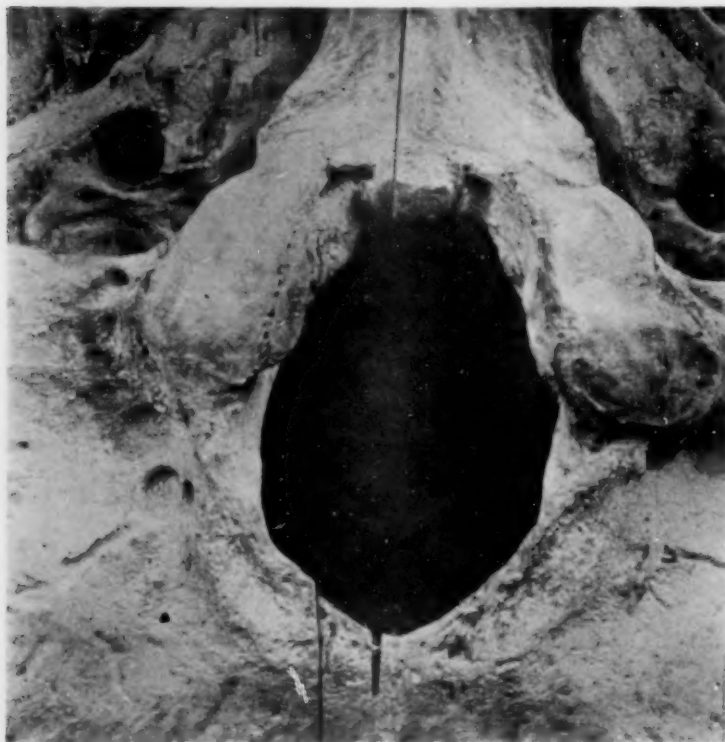
FIG. 4b.—W. R. U. No. 668, female, Negro, thirty-seven years. An example of a long odontoid articulating with the margin of the foramen magnum. Base of cranium from No. 668. Note the third condyle.

Relation to Other Anomalies.—No. 195 shows no other marked anomalies of the skeleton. No. 337 is a microcephalic individual with a cranial capacity of 870 c.c. The upper jaw has failed to come forward in consequence of the lack of development in the cranium: it is not a malformation of the jaw, but a malposition. The only other skeletal anomaly in this specimen is non-union of the last piece of the sternum. The cadaver showed a greatly distended colon, probably idiopathic in type. In No. 1021 there is fusion of the second and third cervical vertebræ and of the seventh cervical with the first thoracic, both fusions being certainly congenital. Anomalous " separation " of the odontoid is therefore no exception to the general rule among minor anomalies.

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There is no widespread primary defect: it is a perfectly local defect in development.

Origin: Mammalian Evidence.—The various theories have been reviewed by Le Double.[4] They fall into three categories which can be briefly stated:

1. Fracture of the apex.

2. Hypertrophy of the ossiculum terminale with coincident atrophy of the remainder of the odontoid.

3. Persistence of the embryonal condition or atavistic survival of the separation present in lizards and crocodiles.

In spite of the arguments of various authors in favor of a traumatic cause, circumstantial evidence indicates pretty clearly a congenital origin. We have therefore reviewed the life history of the human epistropheus up to the date of fusion of the odontoid elements: this is the subject of the next chapter.

It has been stated that permanent separation of the

FIG. 5.—W. R. U. No. 246, male, White, 10 months. Relations of cranium, occipito-atlantal ligament A, anterior arch of atlas B and odontoid process C. The odontoid is hour-glass shaped. Probably no bone formation in ossicle but dense cartilage.

odontoid is long continued if not constant in Monotremes and some Marsupials (Le Double, p. 145). In our experience we have not found this to be true and we desire to submit the following evidence from the Museum of the Royal College of Surgeons, London, in which, by the courtesy of Sir Arthur Keith, one of us had the privilege of studying the relevant material.

Taking first monotremes we find the following examples:

No. 3965, a specimen of ornithorhynchus anatinus identified by us as male, with all epiphyses united except those for the angle of the scapula, the crest and tuber of the os innominatum, the transverse processes of epistropheus and tail and the inter-central epiphyses of the sacrum and tail. In this specimen the odontoid ossicle was complete and fused with the basal part of the process which in turn was fused with the centrum.

A second example of ornithorhynchus is No. 3966. This is a very much younger specimen and of its epiphyses there were none fused, merely the coracoid process beginning to unite with the body of the scapula. It is probable that the epiphyses of the phalanges of fore and hind feet were united, but these bones were missing from the skeleton. At this stage neither there is no union of the odontoid ossicle nor is the basal part united to the centrum.

In a slightly older specimen, No. 3968, the ossicle is united to the basal part which, however, is not yet fused to the centrum proper. In this skeleton not only was the coracoid united to the scapula, but there was fusion of the entire set of distal epiphyses of the humerus and also of the epiphysis for the head of the radius. The phalangeal epiphyses were united and those of the metacarpals and metatarsals were fusing.

Exactly when the basal part of the odontoid unites with the centrum in ornithorhynchus we cannot say. But it was not yet fused in No. 3969 in which the distal epiphyses of the radius, ulna, tibia and fibula were still ununited.

It is quite necessary to mention all the epiphyses named above in order to fix the date of fusion of parts of the epistropheus in the life cycle of the animal.

In Echidna aculeata we find a rather different time relationship. The epiphyses of the phalanges, metacarpals and metatarsals unite before the coracoid fuses with the scapula. Of this stage in the life cycle there are three specimens. In all of them the bodies and neural arches of the vertebræ are in process of union. No. 3957 is a little younger than Nos. 3956 and 3954 which are of the same age. In No. 3957 both odontoid ossicle and basal part are ununited, but in each of the others the former is fused but not the latter. Unfortunately the Royal College of Surgeons collection possesses no specimen giving the date of union of the basal with the centrum.

Among the Marsupials we obtained several important specimens. Three examples bear upon the ossification of the odontoid ossicle. In all

FIG. 6.—Fœtal vertebral column from W. R. U. No. 0.223. The two centres for the odontoid base are fused. Upper and lower depressions and the central vacuity indicate the bilateral nature.

three the third molar (not the fourth) is erupting. In No. 3656, Phascolarctos cinereus, there is commencing union of vertebral bodies with neural arches and the odontoid ossicle is but little if any ossified. In No. 3735, Macropus billardierii, these parts of the vertebræ are fused; there is a small ossific centre for the greater tuberosity of the humerus and that for the medial epicondyle is just beginning to ossify. In this example the apical part of the odontoid has a small bony centre. In No. 3656A, Phascolarctos cinereus, the odontoid ossicle is fully formed but not yet united. The centres mentioned in the humerus are already further developed. Exactly when the odontoid ossicle unites we cannot say, but we have found No. 3652, Phascolarctos cinereus, which shows complete union of the coracoid and primary centres for the os innominatum together with commencing union of the medial epicondyle of the humerus: all epiphyses of long bones in hands and feet are united and the fourth molar is erupted but not worn. In this example the odontoid ossicle is united and there is beginning fusion of the basal part with the centrum. The union of the coracoid is often preceded in Marsupials by fusion of the primary elements of the os innominatum as shown by No. 3724C, Macropus bennetti. We can fix the time of union of the basal part of the odontoid with the centrum by No. 3652 above and also by No. 3861, Thalacomys minor, and No. 3875, Perameles nasuta. In the former the

basal odontoid is uniting, in the latter it is still free. No. 3861 shows recent union of the medial humeral epicondyle together with fusion of the distal humeral epiphyses and those for the proximal ends of radius and ulna. In this specimen the coracoid is still ununited. It is obvious that all these epiphyses fuse just about the same time, the exact order of sequence being subject to some variation. In No. 3875, a bandicoot of about the same age, coracoid, primary acetabular elements, distal humeral epicondyle and head of radius are all united and there is beginning union of the medial humeral epicondyle. In No. 3724C the third molar is erupted, the fourth is still deep in its crypt. In No. 3861 the skull is missing and in No. 3875 the fourth molar is already erupted and worn.

We should also mention No. 3630, Phascolomys wombat, a specimen with fourth molar erupted and worn. This shows beautifully the typical marsupial ventral extension of the odontoid ossicle now fused: it has an as yet ununited basal part. Primary acetabular centres, coracoid, medial epicondyle and distal epiphysis of humerus are all united and the head of the radius is fusing. There is another example of Phascolomys wombat with no number, slightly younger than the foregoing, which shows beginning fusion of basal odontoid with centrum. In this the only united epiphyses are the coracoid and the third phalanges: the acetabular centres are in act of fusing.

Among other lower mammals we have found two examples of rodents, the

FIG. 7.—W. R. U. No. 211, female, White, eight months post-natal. The central vacuity and lower depression are lost, the upper is much deepened.

evidence from which would be useless alone but fits into its place in the present survey. A very young specimen of Hydrochoerus capybara, without number, has no union of either odontoid ossicle or basal part. In it the third molar is erupting, the terminal phalanges are fused, the second are fusing, but as yet there is no union of epiphyses of long bones, coracoid or primary acetabular elements. In the other specimen, namely No. 3253A, Coelogenys paca, the odontoid ossicle is fused and the basal part is just united, the third molar is erupting, the terminal phalanx only is fused, and of the other epiphyses mentioned merely the distal humeral epicondyle is united but the medial epicondyle and the primary acetabular centres are fusing.

Taken altogether these specimens indicate that union of the basal odontoid with the epistropheal centrum follows rapidly after fusion of the odontoid ossicle with the basal part. Further these fusions occur at or near the time of union of the distal epiphyses of the humerus, the coracoid and the primary acetabular centres and also close in time to the eruption of the last molar tooth. Now in man these features are spread over several years in the teens, say fourteen to seventeen years (Stevenson), but we shall find that in man union of the odontoid ossicle certainly occurs by twelve years, and it may be

(our own observations indicate it), at six years, but fusion of the odontoid base with the centrum occurs between the fourth and sixth years. Judging by the latter fact, we must postulate some considerable modification in man of lower mammalian time relationship in union of the epiphyses and fusion of the epistropheal parts. From our own scanty observations in man we should say that there is a typical mammalian time relationship in union of the odontoid ossicle with the base, on the one hand, and between the odontoid base and the centrum on the other. But if the observations of others regarding delay and erratic date of union of the ossicle be borne out by future work, we would have to interpret it as evidence of retrogression. This question cannot be further discussed before the observations on man have been set down.

Fig. 8.—W. R. U. No. 0.95, sex ?, White, four or five years. The centre for the ossicle is growing. The combined basal centres would shortly have united with the centrum and lateral processes.

Life History in Man.—There is no doubt about the early stages in ossification or indeed about the main facts.[3] A single centre for the centrum appears about the third foetal month, twin centres for the base of the odontoid at the fourth or fifth month. These fuse with the body between the fourth and sixth years. The apical centre appears about the second year and is united at about twelve years. This is the accepted description. We can confirm it all except the data on odontoid ossicle which has been our particular study. In Fig. 6, the central vacuity and the midline depressions above and below are the last traces of the original bilateral character. The gaps between the several parts of the axis vertebra gradually narrow and ultimately fill in with resulting fusion (Figs. 7, 8). The date of appearance of the centre for the ossicle is probably quite variable. In No. 829, the achondroplast, it is already large at two years, much larger and better formed than in No. 0.95 at between four and five years. In other respects No. 829 is not precocious (compare Figs. 8, 12). The date of union is even more variable. In No. 1089 no clue to the original separation remains except the somewhat lighter texture of the bone of the ossicle. In No. 624 the much larger ossicle has yet not become completely ossified and there is at best but little union. In No. 0.222 a third type of ossicle appears with clearly defined margins not yet united. The age of the first is five years, that of the second is six years, but the third is a

specimen without history; it cannot be more than between four and five years. Perhaps it would be safer to state that union occurs certainly before twelve years.

In our studies of epiphyseal union we have found evidence to indicate that erratic time relationship in union is associated with a regressive change. Examples are the epiphyses at the symphysis pubis,[6] at the sternal end of the clavicle, at the vertebral border of the
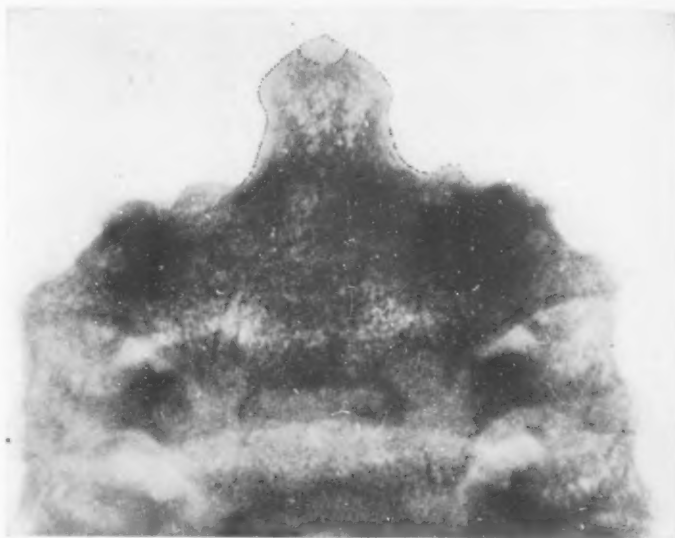
FIG. 9.—W. R. U. No. 1089, female, Negro, five years. The apical centre is fully ossified and united. It is very small and involves merely the tip of the process.

scapula; and to a less extent at the iliac crest and on the heads of the ribs.[5] In view of the findings in Monotremes and Marsupials it is apparent that

there is distinct regression in the more typical mammalian form which is exhibited in man. The erratic time relationship in union bears out this interpretation.

Evidence of Fracture.—It is unnecessary to review fully most of the features which are assumed to give evidence of fracture. The sharp irregular edges

FIG. 10.—W. R. U. No. 624, female, Negro, six years. A large ossicle not yet entirely ossified and but slightly fused with the basal part.

on No. 1021 (Fig. 3) are not those of fracture but of arthritis. The presence of cartilage between the ossicle and the basal part of the odontoid

is of no value as evidence either for fracture or for congenital separation. It is often held, however, that the oblique character of the hiatus indicates fracture: the ossicle is longer in front than in behind. Our studies of the
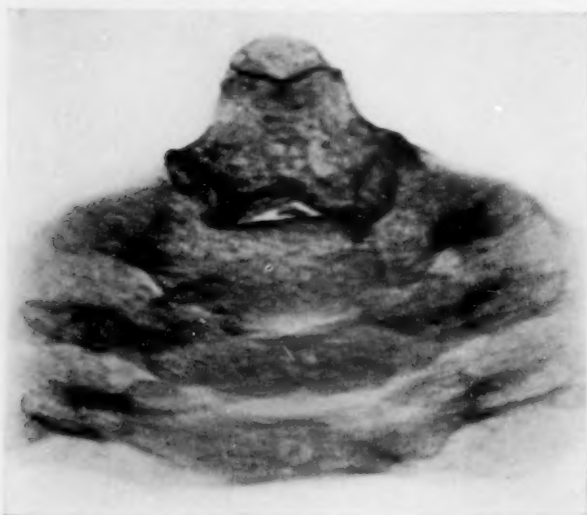
FIG. 11.—W. R. U. No. 0.222. No history, four or five years. A large ossicle fully ossified with clear margins, not yet fused.

monotreme and marsupial condition show this obliquity to be characteristic of the shape of the ossicle, and although we do not happen to be able to present a human specimen presenting this particular f e a t u r e, we have no hesitation in stating that we are not impressed by the emphasis often laid upon this character as evidence of fracture.

The Single Quasi-pathological Anomaly.— In the consideration of anomalies a rather definite grouping makes itself apparent without, however, any very hard and fast outlines. There may be a defect of widespread nature

such as the genit o-urinary anomaly which also affects the vertebral column. At least concomitant anomalies of these two systems are quite frequently discovered. Then there is the anomaly which is frequently but not always bilateral like fusion of lunatum and triquetum in the hand. And finally

FIG. 12.—W. R. U. No. 8296, female, White, two years. Achondroplasia. Ossification is precocious: exuberant connecting cartilage; deformity.

there is the median anomaly like the one under discussion. Examples of all three groups may and often do have a pathological cause invoked for them and frequently color is given to such an interpretation because such

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parts of altered vitality quite readily assume a pathological appearance. They cannot be normal in constitution but they are not pathological in origin.

In No. 1021 the arthritis present is undoubtedly associated with the great age of the individual, but it is quite possibly exaggerated by the fact of the tissue being poor stuff. Arthritis would be expected in the cervical region of any person of eighty-one years, and as there is a joint present here, it is naturally involved.

The two-year-old achondroplast No. 829 is, if anything, rather precocious than otherwise in the amount of bone formation in the ossicle but in common with other cartilaginous sites there is an exuberance of cartilage characteristic of the constitutional condition.

SUMMARY

1. So-called separation of the odontoid process is a congenital defect resulting from failure of the apical ossicle to unite with the rest of the bone and appearing with a frequency of something between once in two hundred, and three times in a thousand specimens.

2. In man as in other Eutherian mammals the ossicle is regressive in nature. This character appears in the erratic nature of the time relationship of its ossification from its first commencement to its final union. It is also apparent in the very variable size of the ossicle. It would not be fair to hold that occasional failure to unite is an evolutionary "throw back" but rather that, in consequence of its regressive nature the tissue itself is poor and liable to defect.

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THE DANGER IN THE USE OF LIPIODOL IN THE DIAGNOSIS OF OBSTRUCTIVE LESIONS OF THE SPINAL CANAL

By William Sharpe, M.D.

AND

Carl A. Peterson, M.D.

of New York, N. Y.

FROM THE DEPARTMENT OF NEUROSURGERY, NEW YORK POLYCLINIC HOSPITAL AND POST-GRADUATE MEDICAL SCHOOL

As a means of facilitating the differential diagnosis and accurate localization of obstructive lesions of the spinal canal and thus particularly of tumors of the spinal cord and meninges, compression of the spinal cord by adhesions of former meningeal exudate and of organization-residue of unabsorbed hemorrhage, together with extradural compression of the spinal canal by traumatic and tuberculous kyphoses, the injection of lipiodol into the spinal theca was first suggested by Sicard of Paris in 1921, and strongly supported by DeMartel. Since then and especially within the past few months, this method of diagnosis has been most favorably discussed in the literature by Sargent, Russell, Babinski, Ironside and Shapland, Laplane, Moniz, Mixter and others. (Vide references.) No unfavorable case reports have been found in the literature and as lipiodol is now being used more and more extensively, we feel it advisable to report our observations in three cases.

Although it is comparatively rare that a surgical lesion of the spinal cord cannot be diagnosed and accurately localized by the usual neurological examinations and especially by careful sensory tests and long before the lesion has advanced to a degree causing a more or less complete obstruction of the spinal canal, yet there are cases where even the most painstaking, thorough neurological examinations and aided by the Queckenstedt and combined cisterna magna—lumbar puncture tests, do not reveal sufficient information as to the character and accurate localization and extent of the spinal lesion to warrant an operative procedure other than an exploratory laminectomy; to avoid the use of the exploratory laminectomy with negative findings and to localize the lesion, when present, most accurately and particularly its upper and lower borders in relation to the vertebræ as early as possible, many substances have been considered for injection into the spinal theca to be outlined about the site of the spinal block by röntgenograms, but no satisfactory material was found until Sicard stated that lipiodol, a 40 per cent. iodine solution in poppy-seed oil and opaque to the X-ray, was safe and non-irritating to the delicate membranes and tissues of the spinal cord.

In the belief that the injection of lipiodol into the spinal theca was a harmless test for the accurate localization of the upper and lower levels of spinal block in selected cases in which no definite diagnosis and localization could be made by careful neurological examinations, 1 cm. of the iodized oil preparation of Lipiodol Lafay, as manufactured by Dr. L. Lafay, Pharmacien,

Paris,* and considered non-irritating to spinal structures, was injected by lumbar or cisterna magna puncture into the spinal theca of three patients— our only three cases in which this method has been used; the results were of definite diagnostic value in all three cases, but in one case such an inflammatory reaction occurred to the arrested lipiodol at the site of the spinal block in the mid-dorsal area that the p a t i e n t 's symptoms a n d signs were aggra-

FIG. I.—V. L. One hour after injection into cisterna magna; elongated globule of lipiodol arrested at the site of spinal block at the lower level of the 7th dorsal vertebra with the patient in the sitting posture.

vated to a degree necessitating its removal at a later operation of laminectomy, at which were disclosed two encysted globules of lipiodol surrounded by numerous newly f o r m e d adhesions. The fact also that lipiodol in this case was temporarily, at least, non-absorbable w i t h i n a period of five and one-half months, aroused our interest in ascertaining (a t a n interval o f 15 months) whether the lipiodol injected in the other two patients was

FIG. 2.—V. L. Five and one-half months after injection; two small globules of lipiodol persisting at site of spinal block with marked signs indicative of an acute spinal cord compression at that segmental level.

still unabsorbed—as it proved to be. Röntgenograms of all three patients now

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* Chaussee d'Antin, Paris. Maison M. Leczinski y Cie., 67 Rue de la Victoire, Paris. The lipiodol in ampule form was of clear transparent golden color aseptic and chemically correct.

reveal the unabsorbed lipiodol in the spinal canal even after an interval of 15 months following the injection, and since it was found encysted and surrounded by fibrous tissue of an inflammatory reaction in the first case, as disclosed at operation in the mid-dorsal area, and changes of posture do not affect the position of the lipiodol in numerous röntgenograms in the other two cases, strongly
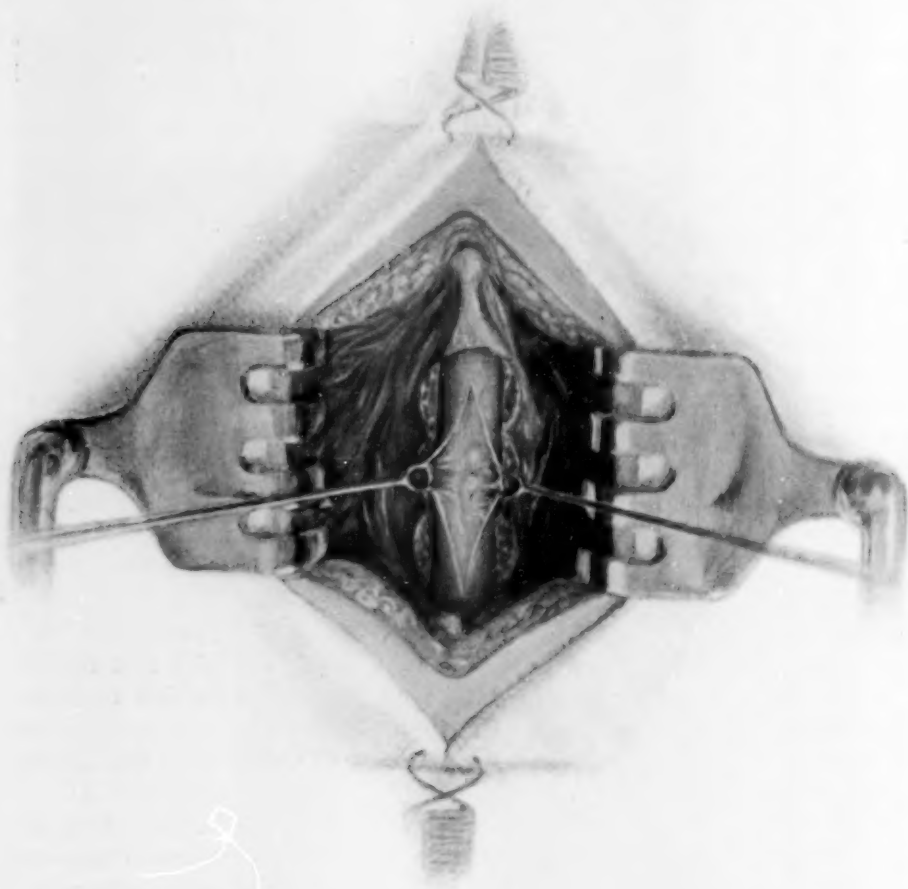
FIG. 3.—V. L. Five and one-half months after injection; operative exposure of the encysted two globules of lipiodol at laminectomy disclosing the extensive inflammatory reaction to its presence and the cause for the compression myelitis.

suggest that the unabsorbed lipiodol is also encysted in these two cases; however, since the lipiodol was injected in these two patients by lumbar puncture, it has fortunately collected in the lowest portion of the spinal theca in the sacral cul-de-sac, so that the symptoms and signs of its presence are not marked. Our experience, therefore, is indeed discouraging—not with the idea and method, as it designates early and accurately the lesion and its extent in relation to the vertebræ—of the greatest surgical value, but with the substance lipiodol itself used for the injection, and it is our opinion that lipiodol in its present

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irritating and non-absorbable form should not be used—or at least, if no other satisfactory substance for injection can be found, then used only at lumbar puncture with the patient in the Trendelenburg position, so that, unabsorbed, it can later sink to the less important structures neurologically of the cul-de-sac of the caudal spinal theca, and its presence produce little or no harm clinically; also used as a last resort to confirm the neurological findings in those cases where a subsequent operation is most probable, so that this irritating, non-absorbable " foreign body " can be entirely removed; or, better still, in doubtful cases, the utilization of the former operative proced- ure of exploratory laminectomy. The use of air injected into the spinal theca by lumbar and cisterna puncture may be suffi- ciently satis- factory for röntgenograms in many cases until a safe non-irritat- ing and absorb- able substance has been found for such injec- tions.

The method employed in the following three patients has been the same: 1 cm. of lipiodol was introduced into

FIG. 4.—V. L. Sixteen months after injection; round globule of lipiodol still persisting at site of operation at the level of the 8th dorsal vertebra; im- movable with change of position and most probably encysted; increasing signs of spinal cord compression at this segmental level.

the spinal theca by cistern or lumbar puncture and by elevating the head and shoulders or by lowering the head and shoulders, respectively, the lipiodol gravitated quickly toward the level of the suspected spinal block. When this heavy oil was injected by cisterna puncture, the patient's head and shoulders were elevated to the sitting position; when introduced by lumbar puncture, the hips were elevated with the head and shoulders lowered in the Trendelenburg position. In the presence of complete spinal block, the lipiodol was thus arrested at the upper and lower levels and early subsequent (from 1 to 24 hours after injection) X-ray examina- tions of the spine revealed the globules of lipiodol. The gravitation of the lipiodol in the absence of spinal block is rapid—within 5 to 7 minutes through- out the spinal canal. In the presence of partial thecal obstruction, such as caused by adhesions of unabsorbed hemorrhage and meningeal exudate, the lipiodol may be temporarily arrested and then be filtered slowly past the point

of partial blockage; numerous particles of lipiodol may be indicative of adhesions. Introduction of lipiodol by lumbar puncture necessitates the uncomfortable head-down position following the injection in order to maintain the oil at the lower level of spinal block during the subsequent examination, whereas the injection of lipiodol into the cisterna magna permits the comfortable sitting posture to be maintained until the clinically important upper level of the spinal block has been accurately localized by the X-ray.

The use of lipiodol on this service has been effective in demonstrating the level of spinal block, but it has been noted that the presence of this iodized oil preparation in the spinal theca has resulted in the aggravation of clinical symptoms and signs as demonstrated by the following case-reports:

CASE I.—V. L., male, white, thirty-seven years of age, l a b o r e r, was admitted to the Polyclinic Hospital in t h e Neurosurgical Department, May 5, 1924, on account of difficulty in walking, owing to stiff and unsteady gait. Fourteen years ago he fell a distance of 30 feet and suffered a depressed fracture of the r i g h t frontal bone and a fracture-dislocation o f t h e

FIG. 5.—V. L. Sixteen months after injection; conical suppository-shaped globule of lipiodol still persisting unabsorbed in the lowest portion of the spinal cul-de-sac; vesical incontinence.

upper dorsal area of the spine; unconscious for two weeks and in the hospital for three months; the depressed frontal bone was removed and a plaster jacket was applied to the back. No residual paralysis.

Two years ago, he noticed a dragging of the right foot and three months later a similar dragging of the left foot; later, there appeared a numbness of the left lower leg, with impaired sensation to heat and cold. Early fatigue upon walking. During the past four months a definite stiffness of both legs—left more affected than right, was noticed, and this has gradually increased, but not to the degree of necessitating the use of a cane. No vesical or rectal disturbance.

He is a well-nourished man of the round-shouldered type. Heart and lungs negative. Wassermann test negative. Spastic rigidity of both legs, left leg worse than

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right. Definite kyphos in the upper dorsal area of the spine—the wedge being most marked at the fourth dorsal vertebra.

Neurological Examination.—Deep reflexes: patellar equally hyper-active with transient clonus; inexhaustible ankle clonus; double Babinski and Chaddock. Triceps and biceps reflexes present and equal. Skin reflexes: epigastric and abdominal reflexes absent; cremasterics present. Romberg test—suggestive swaying. No ataxia or tremor of upper extremities. Pupils—equal and react normally. Fundi—negative. No nystagmus. Speech—normal.

Sensation.—Bilateral hypæsthesia and hypalgesia up to eighth dorsal segment—left more affected than right. Thermoanæsthesia up to left twelfth dorsal and thermohypæsthesia from left twelfth to ninth dorsal vertebræ.

May 7, 1924.—To ascertain the presence or not of suspected spinal block of traumatic origin, most probably in the area of the eighth dorsal segment in spite of the kyphotic wedge being greatest at the fourth dorsal vertebra, a puncture of the cisterna magna was performed; the pressure of the cerebrospinal fluid registered 14 mm., using the mercurial manometer; 1 c.cm. of the iodized oil preparation of lipiodol was injected and the patient placed in the sitting posture; one hour later, röntgeno-

Fig. 6.—A. B. One hour after injection at lumbar puncture and the patient placed in the Trendelenburg position; four oval globules in the lumbar theca and several small indistinct globules at the site of spinal block at the level of the 10th dorsal vertebra.

grams disclosed an elongated globule of lipiodol at the lower level of the seventh dorsal vertebra (*Vide* Fig. 1). No complaints due to the injection.

May 14, 1924.—Exploratory laminectomy at upper level of the spinal block and to the site of the maximum kyphosis; removal of the laminæ of the fourth, fifth and sixth dorsal vertebræ disclosed a definite kinking of the cord at the site of the kyphos with fibrous thickening of the arachnoid; no adhesions. Patient discharged within the usual time, but during the following five and one-half months his condition became worse—spasticity increased, gait became less steady and slight impairment of urinary control.

October 22, 1924.—Examination now indicated a more marked compressive lesion at the eighth and ninth dorsal segments. Röntgenograms disclosed two globules of unabsorbed lipiodol at the lower level of the seventh dorsal vertebra and change of position did not alter their intraspinal relations. (*Vide* Fig. 2.) For fear that the probably encysted

lipiodol might be an etiological factor in the increase in symptoms and signs of this patient, an exploratory laminectomy was again advised.

October 24, 1924.—The laminæ of the seventh to the eleventh dorsal vertebræ were removed, and, upon incising, the dura at the site of the eighth dorsal segment were exposed many adhesive bands between the dura and the thickened arachnoid and pia. Posteriorly to the spinal cord and slightly to the right of the midline were two bulbous enlargements; upon incising their fibrous cystic walls, the golden oil of lipiodol extruded in drops (*Vide* Fig. 3). An effort was made to separate all the adhesive bands. Usual closure.

Last Examination.—September 18, 1925. During the past eleven months since the operation the condition of the patient has become worse—spasticity more marked, so that he requires cane and crutch; vesical incontinence. Röntgenograms now disclose one round globule of lipiodol at the level of the eighth dorsal vertebra (*Vide* Fig. 4); also a conical globule of lipiodol in the lumbo-sacral region (*Vide* Fig. 5). Owing to the marked progression of this patient's condition, it is questionable whether another operative attempt should be made to remove all of the lipiodol—not exposed and removed at the preceding operation.

The surprise and also the disappointment experienced by us in finding globules of lipiodol in this patient over one year after injection into the spinal canal, and especially his condition becoming definitely worse following its use and localized to the site of the encysted lipiodol in the dorsal area, led us to investigate the present status of the following two patients whom we had injected sixteen months ago.

FIG. 7.—A. B. Fifteen months after injection; large oval globule in lowest portion of spinal cul-de-sac with numerous small globules along the lateral portion of the lumbar theca persisting unabsorbed; vesical urgency present.

CASE II.—A. B., male, white, thirty-eight years of age, storekeeper, was admitted to the Hospital for the Ruptured and Crippled on the service of Dr. Royal Whitman, March 4, 1924, on account of persistent pain in the lumbar region and extending into the right leg.

Four years ago he began to experience dull, aching pain in the lumbar region, especially after retiring. After two years the pain gradually became so severe and of a shooting character down the right leg that he was obliged to stop work. Five weeks before admission, a back brace permitted him to get about, but the pain persisted. No urinary difficulties. He was well developed and nourished. Heart and lungs negative. Wassermann test negative. Definite rigidity in the dorso-lumbar area associated with tenderness.

Neurological Examination—Bilateral toe-drop with steppage gait more marked in right leg. Deep reflexes: patellar hyperactive but equal; double exhaustible ankle clonus; no Babinski. Abdominal skin reflexes present—right less active than left. Sensation: indefinite area of hypæsthesia in the right fourth lumbar distribution and a hyperæsthetic

band of two inches in width extending from above the umbilicus in the midline to the right mid-axillary line. Fibrillary twitchings present in both thighs.

Local examination disclosed distinct tenderness from the tenth dorsal to the first lumbar vertebræ. Röntgenograms were positive—one focus of tuberculosis at the ninth and tenth vertebræ and the lower focus at the twelfth dorsal and first lumbar vertebræ— the kyphotic wedge being more marked at this lower focus.

May 6, 1924.—To determine if the suspected spinal block was present, a lumbar puncture was first performed, using the Queckenstedt test, which was positive; then a cisterna magna puncture was made to complete a combined cistern-lumbar puncture, and it, too, was positive for spinal block.

May 8, 1924.—In the hope that lipiodol might outline the lower level of the spinal block, I c.cm. was injected at lumbar juncture and the patient placed in the shoulders-and-head-down position; one hour after injection, röntgenograms disclosed several globules of lipiodol in the lumbar theca and two small globules arrested at the level of the tenth dorsal vertebra (*Vide* Fig. 6). For two days, the patient had increased pain in the lumbar area and in both legs. (Unfortunately, no lumbar puncture was performed to note the cell-count of an inflammatory reaction.) In the hope that a spinal fusion operation might improve the condition, this was performed by Dr. Armitage Whitman,

Fig. 8.—S. T. Sixteen months after injection at lumbar puncture; large irregular globule of unabsorbed lipiodol at lowest portion of spinal cul-de-sac with numerous particles in the lower lumbar theca; vesical irritability and loss of sexual power.

from the seventh dorsal to the third lumbar vertebræ, and an excellent operative result was obtained; plaster jacket applied and finally the usual corset. The condition of the patient improved gradually, so that he was able to attend to his business. The steppage gait became less marked, and the former pain lessened in severity; there has developed, however, a vesical urgency.

August 4, 1925.—Patellar reflexes absent. No Babinski. Sensation—hypæsthesia over dorsal surfaces of both feet. Vesical urgency continues.

August 23, 1925 (fifteen months after injection of lipiodol).—Röntgenograms reveal presence of large globule of lipiodol in the cul-de-sac of the spinal theca and several smaller lateral globules up to the third lumbar vertebra. (*Vide* Fig. 7). Permitting the patient to assume the Trendelenburg shoulders-and-head-down position for one hour does not change the position of the lipiodol—the shape of the large globule merely being altered. (Undoubtedly, the lipiodol has become encysted.)

CASE III.—S. T., male, white, thirty-eight years of age, needle-worker, was admitted to the Hospital for the Ruptured and Crippled on the service of Dr. Royal Whitman, April 20, 1924, on account of persistent pain in thigh and stump of right leg amputated just below the knee.

For ten years he has had pain in the right lower leg with ulceration, and finally, in 1923, the right leg was amputated just below the knee. Shooting pains in right thigh to stump and slight ulceration of stump caused him to apply to the hospital for admission; slight vesical urgency.

He is well developed and nourished. Heart and lungs negative. No evidence of vascular disease. Wassermann test negative. Stump of right leg slightly reddened and tender.

Neurological Examination.—Deep reflexes: patellar present and equal; left Achilles reflex active; no Babinski. Biceps and triceps reflexes present and equal. Sensation: definite anæsthesia and analgesia over perineum and in the distribution of the right first, second, third, fourth, and fifth sacral segments.

May 8, 1924.—Suspecting a lesion of the cauda equina, and in the hope that lipiodol might aid in its localization, one c.cm. was injected by lumbar puncture into the spinal theca and the patient placed in the Trendelenburg shoulders-and-head-down position for twenty minutes; röntgenograms now disclosed the globules of lipiodol at the level of the seventh cervical vertebra, and, upon the upright posture being resumed, then the lipiodol quickly collected in the lowest portion of the thecal cul-de-sac with no arrest in the area of the cauda equina. For two days the patient complained of severe pain in the lower lumbar area and down the left leg, requiring the use of morphine. (It would have been interesting to have performed a lumbar puncture at this time to note any increased cell count, etc.) During the past sixteen months, the general condition of the patient has improved, but the shooting pains have extended to the left thigh and left lower leg, with an increased vesical irritability and loss of sexual vigor.

September 23, 1925 (sixteen months after injection of lipiodol).—Röntgenograms (*Vide* Fig. 8) reveal the unabsorbed lipiodol in the lowest portion of the thecal cul-de-sac as located immediately following the injection, and upon the patient being placed in the shoulders-and-head-down position for one hour, yet no alteration in its position results, merely a change in its form due to gravitation—the lipiodol undoubtedly being encysted with the lower portion now more swollen than the upper part.

CONCLUSIONS

It is realized by us that three cases are indeed a small number from which any definite conclusions may be drawn, and yet since the lipiodol used has been tested and has been reported aseptic and chemically pure, the complications observed concerning the inflammatory reaction to its presence in the spinal theca, even necessitating in one case an attempt to remove it by a laminectomy, makes it advisable to express at least a word of caution regarding its use and especially as an early, routine and confirmatory method of diagnosis. The fact that it is apparently non-absorbable is in itself a potential danger.

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THE RADICAL BREAST OPERATION WITH THE ENDOTHERM KNIFE (ACUSECTOR) AND WITHOUT LIGATURES

By Howard A. Kelly, M.D.

AND

Grant E. Ward, M.D.

of Baltimore, Md.

FROM THE HOWARD A. KELLY HOSPITAL

In developing any new radical operation for the malignant breast, it is not likely that the extirpative Halsted-Willy Meyer procedure will be notably improved. Changes in technic, however, are always possible, improving important details; especially welcome are those which tend to shorten the duration and to lessen the likelihood of infection, as well as the chance of disseminating the tumor cells. We believe we have such an improvement in the radical breast operation in the new endothermic methods.

We have recently done a number of radical breast operations, as well as excised various suspicious nodules, using electrothermic methods alone, securing primary union in all but one, a simple amputation in a fat patient. In the radical procedures the axillary and infra-clavicular tissues were also completely dissected out with the endotherm knife; in some the large pectoral

Fig. 1.—Pointed active electrodes designed especially for use as acusectors. These are made shorter than the ordinary electrodes used in electro-surgical work so as to more nearly approach the size and weight of the scalpel. The core is of brass and carries a steel needle in one end and is fitted for the attachment of the rubber insulated wire in the other end. Any size or shape of needle may be used. The body of the electrode is made of hard rubber or fibre.

muscle was denuded of its investing fascia and was left skeletonized.

Underlying Electrical Principles.—As the electrical principles involved in

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the endotherm "knife," which we prefer to call an acusector—cutting with a needle—have been fully described by Dr. Geo. A. Wyeth, its originator (*Amer. Jour. Electrotherapeutics and Rad.*, May, 1924, pp. 186–187), and later by Ward (*Jour. A. M. A.*, Feb. 28, 1925, vol. lxxxiv, No. 9), we here refer but briefly to the principles involved. The "cutting" which is effected by a high frequency undamped current, is not a true cutting but a molecular disintegration of the tissues at the point of contact, an arc being formed between the tissue and the tip of the needle which is held just over the tissues. This is an essential feature, for without the arc there is no "cutting" or division, but in its place a small area of coagulation around the needle. We have thus an entirely new element in our technic to be acquired skilfully only with practice, as the habitual impulse to make pressure (as in using a scalpel) is for a time almost irresistable. The acusector imparts a new sense, that of feeling the tissue separating or yielding apparently spontaneously before the point of the needle.

Technic.—The type of incision is immaterial—whether from breast to axilla or *vice versa*. The skin wound is planned and made as the needle follows the separation of the tissues. The skin and fat open with remarkably little hemorrhage from the lesser cutaneous vessels while skin flaps are lifted easily from the chest wall to any desired extent with great facility. Larger vessels which persist in oozing are caught with pointed Halsted clamps and are left to be dealt with later. If the larger pectoral muscle is left as the overlying structures are lifted, it is found to be curiously bared of its fibrous

FIG. 2.—Kelley's comb used in dissecting the axilla.

investment by the current, and obviating any special fascial dissections.

The axilla is dissected clean with the acusector without injury to the larger vessels and nerves, which should be protected by a wooden or hard rubber spatula, pressing them to one side, in order to insulate them completely from the current, for there is here a danger which must be sedulously avoided, namely that of a twitching muscle throwing the point of the needle against

the axillary artery or vein. Should this occur, a hole would appear instantly, with a hemorrhage proportionate to its size. To avoid this risk the type and strength of the cutting current can be easily altered in one or both of two ways: first, by reducing the voltage passing through the filament of the DeForest tubes the temperature is lowered and less current passes through the grid circuit, which carries the cutting current; second, the grid circuit can be
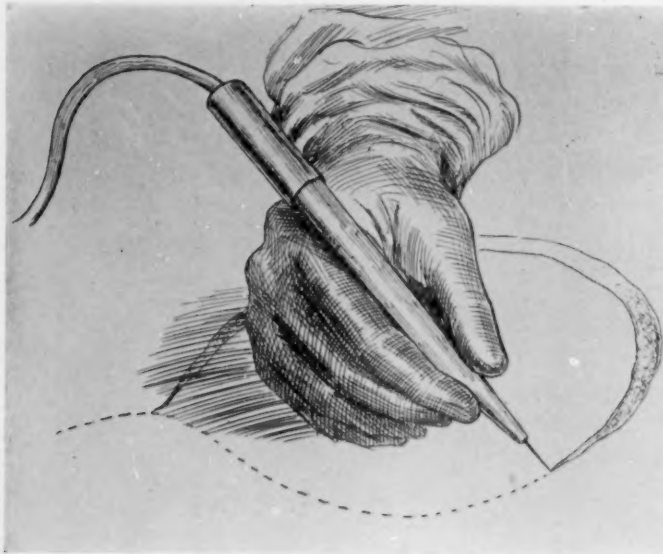
Fig. 3.—Making the skin incision with the acuseter. Notice how the tissues part at the lightest touch of the needle.

thrown partially out of " tune " with the induction coil transformer circuit by varying the tuning coil as indicated by the Neon light. In this manner an exceedingly fine spark is obtained for most delicate dissections. A most valuable aid in skeletonizing this area is found in the axillary comb (H. A. Kelly, ANNALS OF SURGERY, July, 1906, also see photo), which is used with far greater safety and rapidity than any other instrument, quickly baring the
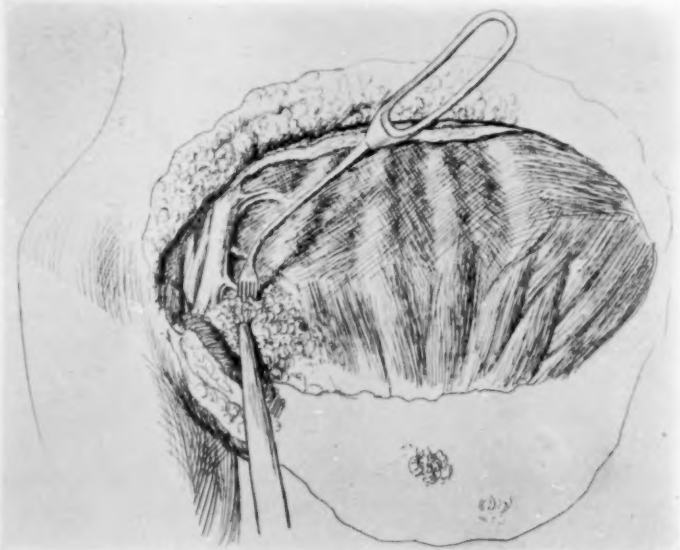
Fig. 4.—The Kelley comb skeletonizing the branches of the axillary vessels.

vessels and isolating them from the large artery and vein and separating the nerves. These vessels are clamped and divided (not ligated) to be treated later.

Hæmostasis.—After removing the breast and the axillary glands *en masse* with or without the pectoral muscles, a complete hæmostasis is secured by a rapid new method described by Ward (*Medical Journal and Record,* April 15, 1925). The clamps left on the bleeding vessels are lifted one by one in the operator's left hand and held at right angles to the patient's body while the right hand applies the active needle electrode switched over to the coagulating (damped high frequency) current momentarily to each clamp. The current flows down and off the point, striking the vessel held in its jaws. The measure of the duration and amount of current applied is a slight hair-like ring of coagulation at the point of the clamp. With this secured the current is shut off by l i f t i n g the needle and the clamp removed. T h e time consumed is a b o u t one-half or one-third that required to place a ligature. One avoids in this way the introduction of the foreign l i g a t u r e material, which is always objectionable when avoidable. There is also the economic saving of ligatures, and of the time spent in their preparation. By observing t h e s e principles a c o m p l e t e breast operation has

Fig. 5.—Illustrates hæmostasis without suture by running the coagulating current down the clamp.

been done without using a single ligature of catgut or silk. The wound in the case being described was closed with the usual drain when the incision healed per primam. Considerable serum collected beneath the skin flap due to insufficient pressure of the dressing, but this ceased in a few days without infection or secondary hemorrhage.

Another precious use of the coagulation current is to destroy any densely adherent gland *in loco* by plunging the needle into it at one or more points, thoroughly cooking the whole interior (H. A. Kelly). Infected tissues, difficult to remove by dissection, can also be treated in this way, both sterilizing them and destroying the disease. This is a field of great promise which, however, requires experience and must be tried out carefully.

Warnings.—The current used in the acusector causes muscular contractions when applied to nerves or muscles. By reducing the voltage as recommended such contractions are so far reduced as to be negligible. The

coagulating (damped) current necessarily causes marked contractions when used near a muscle, which can easily injure a vessel or nerve by a sudden contact; *verbum sapienti satis est.*

Fig. 6.—Photo of healed incision after radical breast operation without a ligature using the technic of coagulating blood-vessels described in text.

Advantages.—1. Lymphatics, capillaries and small blood-vessels are s e a l e d, limiting the number of clamps applied. There is reasonable hope that this closure of the lymphatics will lessen the liability to local recurrences.

2. Few or no ligatures used. The elimination of ligatures helps keep hands out of the wound. The operation can thus be done with hands at a distance, lessening the chance of infection.

3. Primary union is the rule; the actual depth of tissue destruction on each side of the acusector is one-tenth millimetre. It is easily possible that primary union is promoted because of sterilization of the skin edges.

4. The reduction of ligature material is no mean economical saving.

OBSERVATIONS ON THE TREATMENT OF GALL-STONES*

By Kenelm H. Digby, F.R.C.S., Eng.

of Hong Kong, China

HO TUNG PROFESSOR OF CLINICAL SURGERY AND PROFESSOR OF SURGERY IN THE UNIVERSITY OF HONG KONG

FEW operations give greater satisfaction to patient and to surgeon alike than does a successful operation for gall-stones. And, one may add, few experiences are more distressing than failure of the operation to procure relief.

A small calculus overlooked leading to a recurrence of all the symptoms; a mucous fistula due to a timid cholecystostomy; obstructive jaundice or total biliary fistula from damage to or ulceration of the ducts.† These are the dreads of the surgeon, and each demands a further and maybe more difficult and dangerous operation for its relief. I do not suppose any surgeon who has had to deal with a large number of these cases has been so fortunate as to escape all such disappointments.

This paper advocates certain steps designed to obviate the risks of such mishaps. Some of these measures are unconventional, but they may have been slowly developed as the logical result of experience.

The first plea is for prompt and early operation. The presence of gall-stones is not usually regarded as a condition demanding *immediate* operation. Instead if an attack of biliary colic is actually in progress many surgeons seem to prefer waiting until the attack has subsided. Yet this hesitation involves certain definite risks:

1. During the attack a stone may pass from the cystic duct into the common bile duct and float about in the common bile and common hepatic ducts. Attacks of obstructive jaundice are liable to occur and a biliary type of cirrhosis of the liver sets in. The case now assumes a graver aspect both from the point of view of immediate operative mortality and of subsequent morbidity. Cases with stones confined to the gall-bladder treated by routine measures have a 2 per cent. surgical mortality.

When the stones have passed on into the common bile and the common hepatic ducts the operative mortality may reach as high as 10 per cent.

2. A stone may become impacted at the ampulla in a patient (where the anatomical arrangements permit) in such a way as to enable the gall-

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* The substance of this paper was communicated to the Surgical Section of the Joint Conference of the Hong Kong Branch of the British Medical Association and the China Medical Missionary Association in January, 1925.

† Balfour and Ross[1] reviewed 166 cases of post-operative biliary fistula seen at the Mayo Clinic between January 1, 1910, and December 31, 1919.

Eisendrath[2] collected and reviewed fifty-one cases of operative injury of the common and hepatic bile ducts.

Zabola and Bengolea[3] have drawn attention to the frequent injury to the ducts in cholecystectomy operations as also has Walton.[4]

bladder to squirt bile into the pancreatic duct. A true biliary colic may then have passed insidiously into the very serious condition of acute hemorrhagic pancreatitis, which has the terribly high death-rate of 75 per cent. and upwards.

The following case illustrates this point. Mrs. K., aged thirty-eight. Between July and October, patient had had three attacks of colicky pain in the right hypochondrium unaccompanied by jaundice. On Sunday, October 15, at 11 P.M., a fourth attack of pain began. On admission to hospital on Monday morning the temperature was 99.4 and the pulse 84. There was tenderness beneath the right costal margin and a sharp pain at the end of a deep inspiration. The case was regarded as a typical biliary colic and it was decided to wait until the attack had subsided before operation. Next morning (Tuesday) the temperature was 101 and the pulse 106, slight jaundice was present and there was bile in the urine. Immediate laparotomy then displayed extensive fat necrosis, bile-stained peritoneal fluid and great tension in the gall-bladder. As it happened, this patient did recover, but her life had been jeopardized by the delay.
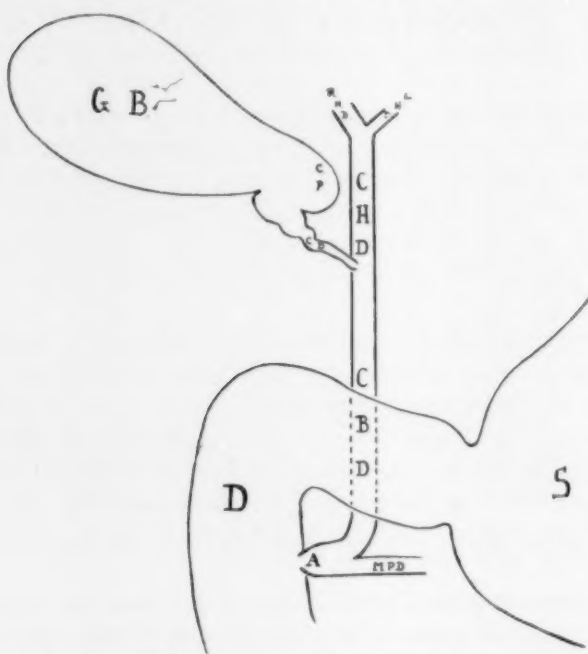
FIG. 1.—Diagram of biliary tract (showing the nomenclature used in this paper). GB. Gall-bladder. RHD. Right hepatic duct. LHD. Left hepatic duct. CHD. Common hepatic duct. CBD. Common bile duct. MPD. Main pancreatic duct. A. Ampulla of Vater. CP. Cystic pouch.

3. Obstruction of the cystic duct may lead to such distention of the infected gall-bladder as to cause perforation or gangrene of the gall-bladder. These again are very serious conditions which would rarely be met with if prompt operation for biliary colic became the general rule.

The following rule may therefore be enunciated:

Whenever a reasonably probable diagnosis of gall-stones can be made, operation should be undertaken at once.

As with every other rule certain exceptions and reservations must be made. In the absence of an acute attack the convenience of the surgeon and the patient can be consulted and the case can wait for a few days. Again, if jaundice is deep or has been present for long, the operation should be

postponed forty-eight hours to permit injections of calcium chloride to be given and other suitable preparation of the patient to be carried out.

The second plea is for *the free-est possible exposure of the biliary tract*. Perthes' incision [5] probably gives the widest approach with least damage to the essential structures of the abdominal wall, namely nerves and aponeuroses, and the following slight modification has been practiced with considerable satisfaction.

A vertical paramedian incision 2 cm. to the right of the middle line is made from the costal margin to just below the level of the umbilicus. The anterior layer of the rectus sheath is divided in the same line and the rectus muscle retracted lateralwards. The posterior rectus sheath is divided close to the linea alba, for if divided further out it is hard to sew up, the stitches easily tearing out. The tendinous inscription obliquely crossing the rectus muscle from near the umbilicus is identified and the skin, muscle and both layers of the sheath divided along or slightly above the line of the inscription. An angled incision is thus made into the abdomen and the more the patient strains the wider gapes the opening, so that no retractors are needed for the abdominal wall. No nerves are cut. The spine can be angled in the lower part of the thoracic region, so bringing the bile ducts forward without tightening the edges of the parietal wound as occurs in a simple vertical incision. Moreover, the posterior part of the rectus sheath can afterwards be securely sutured which is not always the case with the vertical mid-rectus incision.

The third contention put forward in this paper is the most unorthodox, for here it is asserted that the most important routine step at operation for gall-stones or for acute hemorrhagic pancreatitis is *choledochotomy*. A longitudinal incision should be made into the bile duct just above the duodenum. And this is urged on two grounds, namely:

(a) That it is impossible to detect all stones in the main ducts by mere palpation; and

(b) That it enables a T-shaped metal tube to be inserted as a guide, thus avoiding the risk of serious stricture-producing injuries during the following cholecystectomy.

With regard to (a) it may be said that even if there has never been a trace of jaundice, yet a small pebble may have passed along the cystic duct and be floating in the common hepatic or common bile ducts. If jaundice has supervened upon any attack of colic, the possibility of stones in the main ducts becomes a probability. External palpation certainly detects a great many stones in this situation, and if a stone be found it should, if possible, be manipulated into position and made use of in opening the duct. But we cannot exclude the presence of stones with absolute certainty unless the duct be opened.

The gall-bladder and liver are gently raised by means of a broad, flat liver retractor; the first part of the duodenum is pulled downwards and held by a sero-muscular stay suture. The foramen epiploicum is found, the index-finger is introduced and the duct palpated between finger and thumb as far

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as possible. If no stone is found, the foramen epiploicum and the space to the right of the free edge of the gastro-hepatic or lesser omentum is packed lightly with gauze: This saves the right posterior subphrenic pouch from contamination with any bile which may escape. The peritoneum is then incised vertically in front of the free edge of the lesser omentum and the bile duct recognized. Its adventitious sheath is divided vertically and each edge is seized with a pair of pressure forceps which serve to steady the duct when its wall is incised as the next step. A half inch incision is made. (Fig. 2.)

It is remarkable how free this part of the duct system often is from adhesions. I have operated on cases where the gall-bladder and cystic duct were buried in adhesions, where the bile duct had contained calculi for months, and even where the gall-bladder was shrunken and empty, having discharged all its stones into the main ducts, and yet the peritoneum covering this part of the common bile duct was normal and free from adhesions.

Very rarely an abnormally long cystic duct may be opened in mistake for the common bile duct, but no harm will be done thereby. If the first part of the duodenum is pulled downwards and the common bile duct be opened close to the upper border, one is nearly always below the entry of the cystic duct. At this point, too, the portal vein is well over to the left side; but if there is any doubt about the duct, a hypodermic needle should be inserted and fluid withdrawn with a syringe to establish identity. The common bile duct just at the upper border of the duodenum is largely free from any mass of sympathetic nerves (such as lie about the common hepatic duct), so that no shock is produced by manipulation at this

FIG. 2.—Exposure of common bile duct

level in contrast with the marked shock which may follow interference higher up.

Even with the duct opened great care must be exercised if no stones are to be overlooked. If the duct is dilated much beyond its usual quarter inch diameter, the presence of stones is certain. If this dilation is sufficient to permit of it, a slender index-finger may be introduced and should be passed upwards as far as possible, at least as far as the bifurcation into right and left hepatic ducts and should be passed downwards to and as far as possible into the funnel-shaped narrowing at the ampulla. By this means, stones will be readily detected and can be removed with a scoop.

If escape of bile be too free a pair of non-serrated forceps (*e.g.*, the so-called silkworm forceps, Guy's pattern, Down Bros., No. 744) may be used to compress lightly the duct above. These forceps may sometimes be employed successfully in a manœuvre to extract small stones from the hepatic duct. The duct is compressed for a few minutes till swollen with bile; the forceps are then released and small pebbles may be swept out with the ensuing rush of bile.

The ducts should also be explored upwards and downwards with a probe, which must also be passed through the sphincter at the ampulla well into the duodenum. The probe should be easily bendable by hand and should have

FIG. 3.—The type of metal T-tube employed.

an acorn head (with gently sloping shoulders to facilitate withdrawal through the sphincter). Two probes should be used, the acorn heads, respectively, of 3/16 inch and ⅛ inch diameter. Some patterns of Babcock's varicose vein probe answer the purpose well.

Finally when the bile and hepatic ducts are clear of stones a T-shaped metal guide of appropriate size is introduced and the gall-bladder may now be safely dealt with. The exact construction of the T-guide is still in the experimental stage. The form I have used (Fig. 3) consists of a stem or handle three inches long and a cross-piece reaching half an inch beyond one way and one and a half inches the other. The long end is pushed upwards into the common hepatic duct and is bevelled on the side remote from the stem to facilitate introduction. The short end is bevelled on the same side as the stem and passes down into the bile duct and serves the purpose of making the guide self-retaining after introduction. The cross-piece being a tube, enables the passage of bile the usual way without undue leakage. This guide is made in various sizes, ranging by 1/16 of an inch from 2/16 to ¾ of an inch in diameter, and one should be chosen for use which nearly fills the duct in each particular case.

The common bile and common hepatic ducts are now clearly defined to

touch and perhaps even to sight, and there should be little risk of injury during removal of gall-bladder and cystic duct (Fig. 4). Even if such an accident happened the injury would of necessity be slight, readily recognized and easily and quickly repaired. Hence the gall-bladder may safely be removed from the fundus towards the ducts, and moderate traction may be employed with impunity.

At the conclusion of the operation the T-guide is withdrawn, the peritoneum and loose adventitia lightly closed with a plain catgut suture, and the end of a drainage tube placed over the suture line.

The last point to be touched upon here is the question whether the gall-bladder should be removed or merely drained. It is not necessary to recapitulate all the arguments that have been brought forward in the discussion of cholecystostomy *versus* cholecystectomy. Suffice it to say that it is the usual but not unanimous opinion of surgeons that removal of the gall-bladder is desirable for the following reasons:

(1) It is already diseased and a diseased gall-bladder may produce another crop of stones. Eisendrath and Dunlavy[6]

Fig. 4.—The metal T-tube in position, filling, fixing and clearly defining the common hepatic and common bile ducts.

have shown that even the stump of the cystic duct may dilate and generate fresh stones.

(2) It may be the early seat of carcinoma already or it may become carcinomatous. Leitch's recent work[7] in producing carcinoma experimentally in gall-bladders of guinea pigs by inserting calculi therein, supports the early clinico-pathological evidence on this point.

(3) Convalescence is longer and recovery less certain when the gall-bladder is not removed but merely drained. Bland-Sutton[8] quotes Tanner, who in 1914 analyzed 117 consecutive cases of gall-stones in Guy's Hospital, and found patients submitted to cholecystectomy were only half as long in

hospital as those submitted to cholecystostomy. Balfour and Ross,[1] analyzing 166 cases of post-operative fistula, found that in only 10 per cent. had the gall-bladder been removed.

The reasons for this are that with cholecystostomy a small stone may be overlooked in the cystic duct overlapped by the cystic pouch of the gall-bladder, or an ulcer in the cystic duct may produce stenosis leading to a mucous fistula or recurrent cholecystitis may lead to the same complication. It is also true that fewer adhesions are separated and that the presence of the gall-bladder obscures direct external examination of the ducts if the gall-bladder is not removed.

It is undesirable to remove an organ with valuable functions like the gall-bladder, but when gall-stones are present the functions of the gall-bladder are largely in abeyance, and that the body can nearly always compensate successfully for the absence of the gall-bladder is a matter of constant experience.

In practice the real great objection to cholecystectomy is the fear of damage to the common hepatic or common bile ducts, a disaster which has probably happened on hundreds of occasions. The ducts may be damaged at two points:

(1) The junction of the cystic, common hepatic and common bile ducts (Fig. 1). This may be the result of pulling on the gall-bladder and cystic duct when removal from the fundus is being attempted; or to inadequate exposure, or to congenital abnormalities, or to adhesions when it is being removed from the cystic duct end. Or it may be due to stones bulging from the cystic duct into the bile duct with perhaps some prolapse of the cystic into the larger duct.

(2) The common hepatic duct where it lies close to the cystic pouch (see Fig. 1). The pouch overlaps the common hepatic duct anteriorly (or in some abnormal cases lies behind it). The separation of this part of the gall-bladder is extremely easy in a normal body, but with severe cicatrization in this region the cystic pouch may be closely adherent to the common hepatic duct. Possibly a fistulous communication sometimes occurs. It is in these cases that parts of the hepatic duct may be dissected off with the gall-bladder. Or the duct may be crushed with pressure forceps in seizing a bleeding point. Eisendrath[1] and Flint[2] have done very good service in studying and recording the frequent abnormalities of ducts and arteries which occur in these parts, but even helped by the knowledge they have supplied, it is impossible always to dissect out clearly the different ducts, and some method is needed by which the ducts can be clearly and safely defined. It is here that the metal T-guide should be valuable. And this paper advocates its further trial in the hope that with longer experience it will fulfil its early promise of ridding this operation of cholecystectomy of its worst danger.

Of course all strictures of the biliary system are not post-operative. But the preliminary choledochotomy and passage of acorn probe and T-tube will early detect preëxisting ulcerative strictures and lead to their correct treatment.

One must of course not make a fetish of cholecystectomy. If the patient's condition is bad, the dissection of the neck of the gall-bladder is offering great difficulties and no stones are left behind, simple drainage may be the wise course.

Very occasionally a partial cholecystectomy may be preferable, the fundus and body (where nearly all carcinoma begins) being resected without the cystic pouch or cystic duct.

In this part of China intrahepatic stone formation (possibly associated with clonorchiasis?) is not uncommon. In such cases there is no indication to remove the gall-bladder.

I am indebted to my clinical assistant, Dr. S. H. To, for the care and skill he has devoted to the preparations of the illustrations for this article.

SUMMARY

This paper advocates the following principles in the treatment of gall-stones:

(1) The operation should be undertaken *at once* as soon as a reasonably probable diagnosis of gall-stones has been reached.

(2) That very free exposure of the biliary tract is desirable, preferably an angled incision such as Perthes' incision.

(3) That the bile duct should be opened just above the duodenum as a routine measure and the main ducts very thoroughly explored from within as well as from without.

(4) That the removal of the gall-bladder and cystic duct should generally (though not invariably) be practiced, the use of a metal T-tube protecting the main ducts from risk of injury.

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RUPTURE OF AN INTRAHEPATIC BILE DUCT
WITH FATAL PERITONITIS

By Woodruff Smith, M.D.

of Ladysmith, Wis.

FROM THE DEPARTMENT OF PATHOLOGY AND BACTERIOLOGY OF THE YALE UNIVERSITY SCHOOL OF MEDICINE

THE purpose of this communication is to report an instance of spontaneous perforation of an intrahepatic bile duct, following complete obstruction of the common duct. When perforation occurred, the general peritoneal cavity was flooded with infected bile, and a fulminating peritonitis resulted.

Quite parallel instances of this unusual complication of gall-stone disease have been reported in the German literature, but in general it is an unrecognized contingency, and has not been considered along with spontaneous perforation of the gall-bladder and of the extrahepatic ducts, nor has it been brought into relation with other phases of the general pathology of the biliary tract. It is of interest at this time, in relation to a moderately large and increasing group of cases which are being reported as *Bile Peritonitis without Macroscopic Perforation of the Biliary Tract*, or under some title with similar implication.

HISTORICAL

In 1905, Nauwerck, of the University of Leipzig, reported two cases of intrahepatic bile duct rupture which were unexpectedly found at autopsy. The clinical picture in each instance was that of a fulminating peritonitis. The peritoneal cavity contained half a litre of green or brownish fluid which was found to issue from a minute point of perforation on the liver surface. The ampulla of Vater was completely obstructed by a calculus.

Four years later, Karrillon published a description of two more instances (from Nauwerck's Laboratory) in an admirable Inaugural Dissertation. In 1911, Rosenthal reported one instance with exploratory laparotomy and recovery. Vogel reported another in 1913, and Levin still another. In the same year, Nauwerck and Luebke added a fifth to the Leipzig series. Finally, Ermer reported two instances in 1915, bringing the total to ten.

During the same period, Kolisko, Professor of Legal Medicine at Vienna, appears to have seen a number of instances (" eine Reihe von Fällen ") in the course of an extensive experience at the autopsy table. However, he gives the subject only a casual paragraph in a text-book article. Rosenthal refers to a brief note on an instance, from an unstated source in the " earlier literature."

CASE REPORT.—History No. 15738, New Haven Hospital. The patient was an obese white woman, eighty-three years old, admitted on February 19, 1923, for the surgical treatment of supposed intestinal obstruction. She was, however, practically moribund and died three hours later without operation.

After her death, on questioning the relatives, it was discovered that for five years or more, at intervals of several months, she had had acute attacks of epigastric pain, often initiated by a chill. At these times she always became more or less jaundiced, but the pain subsided in a day, and the color of the skin returned to normal rapidly. Aside from her abdominal attacks she had been unusually healthy, and even in her old age was quite vigorous. Her fatal illness seemed at first one of her usual attacks. She became definitely jaundiced soon after onset, yet when a physician was called on the third day, this had faded completely. She was advised to come to the hospital where it was ascertained that her illness of four days began suddenly with dizziness and a short fainting spell, followed by severe and persistent abdominal pain. The only details learned at the time were that there was complete obstipation from the day of onset, and abdominal distention, which could not be relieved by enemas. She complained constantly of thirst, and took fluids well, vomiting once only, on the day before admission.

On examination, the patient was found restless and in pain. The mouth temperature was 100° F. The respirations were rapid but not labored. There was a state of auricular fibrillation, with an apex beat of 180 a minute. The peripheral pulse was too weak to be felt except over the temporal artery. Cyanosis was evident and slight pitting œdema of the ankles was present. The mucous membranes were dry, and the breath sweetish. The lungs were clear. The abdomen was distended and everywhere tender to palpation. No masses, shifting dulness or fluid wave could be made out, while the degree of obesity precluded the possibility of observing peristalsis. Pelvic and rectal examinations revealed nothing. The reflexes were moderately active and equal.

The white blood-cell count was 10,000 with 80 per cent. polymorphonuclear cells. The urine showed a trace of albumin and was strongly positive for sugar, acetone, and diacetic acid. The presence of bile was not suspected grossly. In the urinary sediment were numerous pus cells, a few red blood-cells, and an occasional hyaline and granular cast. The non-protein nitrogen of the blood was 86 mgms., the blood sugar 666 mgms., per 100 c.c.

The opportunity for clinical study was obviously too meagre to allow of a satisfactory diagnosis, but the cardiac irregularity, and the evidence of pancreatic insufficiency were the most impressive findings.

Post-mortem Examination.—Autopsy No. 735. Brady Laboratory, New Haven Hospital. Complete autopsy was performed nine hours after death. For the sake of brevity the protocol is here given in detail only as concerns the pathology of the liver and biliary tract.

The abdominal cavity contained a cloudy dark green fluid whose quantity was estimated at 150 c.c. This fluid was everywhere present except in the lesser peritoneal sac. The intestinal surfaces were slightly granular here and there, but showed only a minimal injection. Small deposits of green-tinged plastic exudate were distributed over the surface of the liver and about the capsule of a small soft spleen. The left border of the omentum was adherent to the parietes in the iliac fossa, and had brought about an hour-glass constriction of the stomach as well as a kink in the transverse colon. From the point of kinking as far back as the cæcum the colon was dilated and thin-walled, while the ileum was moderately contracted. The right border of the omentum was thickened and adherent to the under surface of the right lobe of the liver, covering the gall-bladder region completely.

When the gall-bladder was exposed by blunt dissection, it was found rounded, flaccid, and somewhat enlarged, measuring 9 cm. in length. Stones could be palpated within it, as well as in the cystic and common ducts. On manual manipulation of the gall-bladder and liver, a small additional quantity of the fluid previously described collected in the right renal fossa, but with the organs *in situ* no point of perforation could be found. The walls of the gall-bladder and extrahepatic ducts appeared everywhere thickened and pale. The liver, stomach, duodenum, and pancreas were removed *en masse*. Then the

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right and left hepatic ducts were severed at the hilum of the liver, after proximal and distal ligation.

On opening the duodenum, the terminal portion of the common bile duct, for a distance of two centimetres, was found to project into the lumen of the intestine as a finger-like process. The opening of the papilla was clearly visible at the tip of this process but fluid could not be expressed through it. Cross-section of the proximal third of the pancreas permitted the escape of cloudy green bile from the duct of Wirsung until the gall-bladder was completely drained. Injection of Pick's fluid by way of the pancreatic duct caused the bile ducts and gall-bladder to become distended again without leakage at any point in the tract. The presence of complete obstruction of the common duct was further supported by the milk-white color of the contents of the entire intestine.

After fixation of the specimen, consisting of gall-bladder and ducts, for twenty-four hours in Pick's fluid, the dissection was carried to the point indicated in Fig. 1. The common bile duct measured 12 mm. in diameter, and was joined by a dilated pancreatic duct at the ampulla. The ampulla was blocked distally by a rounded gall-stone which remained fixed in its bed during the dissection. Other concretions lay free in the gall-bladder and in the ducts. The mucosal surfaces were uniformly bile stained and showed a lacy reticulation throughout. There were no ulcers. Microscopically, the thickened walls of the gall-bladder and common duct were diffusely infiltrated with round cells, and gland-like crypts of the epithelial lining were numerous in both structures.

The liver appeared small, and weighed only 1100 grams. Except for a scarred area on the anterior aspect of the right lobe, the capsule was translucent, while the liver substance beneath showed an irregularity of surface in low relief. The cut surface of

FIG. 1.—Complete obstruction of the ampulla of Vater, with dilatation of the common bile duct.

the organ had a brownish-yellow color, and was marked by innumerable darker red dots. Jaundice was evident, the tissue turning green on contact with Zenker's fluid. Nowhere in the parenchyma were there foci which could be interpreted as possible cholangeitic abscesses. In a number of microscopic sections of the liver, slight amounts of fat and deposits of golden pigment within parenchymal cells of the central zone of the lobule were observed. The interstitial tissue of the portal spaces was infiltrated with both lymphocytes and polymorphonuclear cells. Larger bile ducts frequently contained small collections of pus cells and bacterial masses. Here and there ulceration of the mucosa was associated with purulent infiltration of the wall of the duct. Larger lymphatics were filled with pus cells. The branches of the sclerotic hepatic artery and of the veins failed to show thrombi. Definite abscesses of the liver were not found microscopically.

Ruptured Intrahepatic Bile Duct.—Since the extrahepatic portion of the biliary

tract showed no perforation, the liver was more closely inspected; the findings may be described as follows: On the anterior aspect of the right lobe, just over the gall-bladder fossa, there is an irregular area of grayish color whose surface is thrown into shallow folds. The area is broadest at the liver edge and somewhat depressed, but becomes narrower as it extends toward the dome. Within it, 15 mm. above the right border of the gall-bladder notch, there appears a small green-stained papilla with a minute central crater (Fig. 2). On section through the liver perpendicular to the surface, there is found a superficial layer of gray-white fibrous tissue, in which a few prominent blood-vessels are imbedded, together with a plexus of bile ducts recognized by their green stain. One of these ducts leads to the small papilla of the liver surface, and it can be traced, in parallel cuts, across the roof of the gall-bladder fossa. Here it dips down away from the surface to join a primary branch of the right hepatic duct at the hilum. Measuring peripherally less than 1 mm. in diameter, it increases in size as other tributaries join it, to furnish the point of perforation with an extensive drainage of bile by back flow.

FIG. 2.—Chronic and acute cholangeitis and cholecystitis. Rupture of intrahepatic bile duct through Glisson's capsule into the peritoneal cavity.

A block of tissue containing the papilla was imbedded in paraffin, and sections cut serially, 10 micra thick, were stained with hæmatoxylin and eosin. In addition to the gross drawings, accurate reproductions of selected sections have been made by Mr. Armin B. Hemberger. These were chosen at intervals varying from 150 to 210 micra. The magnification of low and high power drawings is approximately 8 and 40, respectively.

A Microscopic Note on the Point of Perforation.—The superficial grayish zone of the liver surface consisted of dense connective tissue in which only blood-vessels and bile ducts are imbedded. Glisson's capsule was sharply differentiated from the underlying connective tissue as a thin membrane occasionally beset by small fibrin masses. This membrane was intact as far as the slopes of the papilla, where it became necrotic, and, with the tissue beneath, bile stained. There was polymorphonuclear infiltration of the connective tissue about the papilla, with small hemorrhages, and an early proliferative reaction had also manifested itself. Bile ducts of various diameters occurred in the scar; the smaller as a rule had a more definite epithelial lining than the larger.

Throughout the serial sections, ramifications of one of the larger ducts lay parallel to and quite near the capsule of Glisson, and passed beneath the base of the papilla. Although the surrounding tissue was œdematous and bile stained, the segment of the duct close to the point of rupture had a well-preserved fibrous wall, partly torn toward the liver capsule. (Sections 1 and 2, Fig. 3.) Bile was found as a golden brown mass within the duct and bridged the tear in its wall. A leucocytic collection appeared only at one lateral angle of the duct. In succeeding sections the duct opened widely into the open crater of the papilla. Here the outward aspect of the duct wall had become necrotic. Bacterial masses and cellular debris were found in the opening. The crater

of the papilla became covered by a necrotic but recognizable membrane and the base was formed by a duct wall. (Section 1, Fig. 4.) From this point the cellular infiltration of the papilla increased, but the major duct shifted its position, leaving only smaller tributaries in the region of the papilla. Finally one of these smaller ducts appeared at the centre of a definite miliary abscess, directly beneath the slopes of the papilla. (Section 2, Fig. 4; Sections 1 and 2, Fig. 5.) The reaction here was essentially purulent, and evidence of bile staining was absent.

From a study of all the serial sections it appeared that the miliary abscess formed
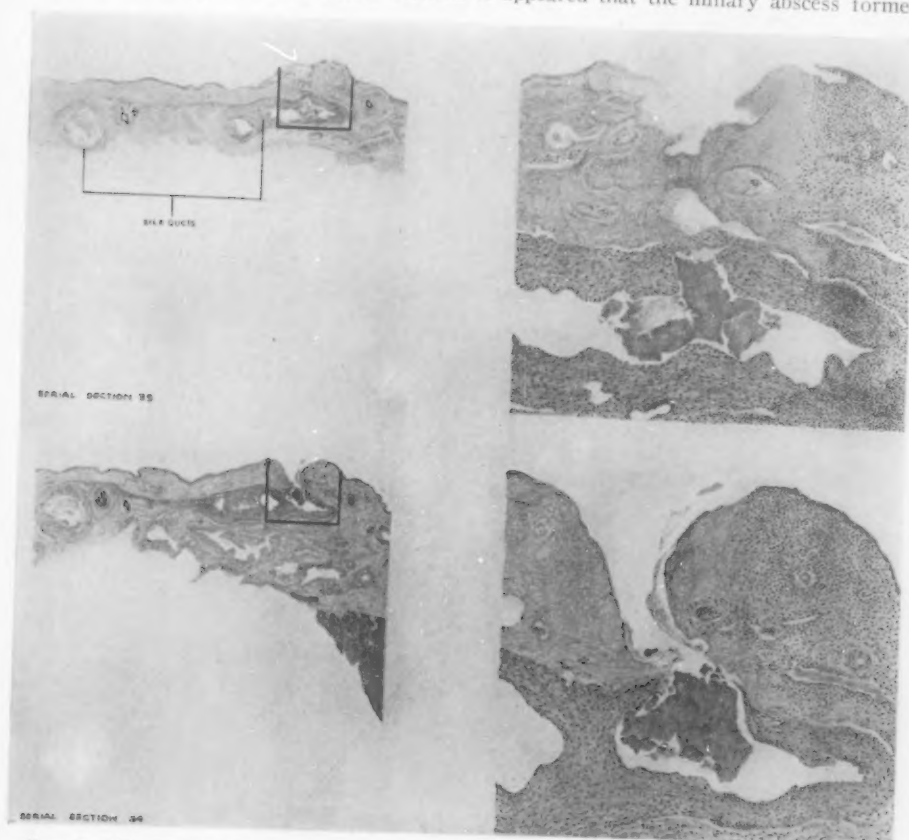
FIG. 3.—Microscopic sections of the point of rupture. The open crater of the papilla may be seen.

primarily in the smaller tributary, and that rupture of the larger duct resulted from subsequent necrosis of the surrounding scar and of the duct wall, under conditions of increased bile pressure due to obstruction of the common duct.

Complete Anatomical Diagnosis.—Primary.—Chronic cholecystitis and cholangeitis with stones; hepatic fibrosis with local dilatation of the bile ducts; calculus obstruction of the ampulla of Vater; jaundice; acute pancreatitis; acute cholangeitis; rupture of miliary cholangeitic abscess with escape of bile into the peritoneal cavity; acute generalized peritonitis; acute splenic tumor; cloudy swelling of the viscera.

Subsidiary.—Senility; generalized arteriosclerosis; fibrosis of the myocardium; pulmonary emphysema; chronic osteo-arthritis; fibrous peritonitis; atresia of the appendix. Lipomatosis of the pancreas with hyalinization and hypertrophy of the insular tissue. Meningeal endothelioma. Lipoma of the transverse colon.

Bacteriological Report.—Cultures of the heart blood and peritoneal fluid remained sterile. Direct smears of the peritoneal fluid showed pus cells, and innumerable Gram-positive streptococci forming long chains.

GENERAL CLINICAL AND PATHOLOGICAL FEATURES

The twelve reported instances of intrahepatic bile duct rupture have occurred in the latter half of life, and ten were in females. There has usually been a past history of biliary colic. The final illness has been sudden in onset
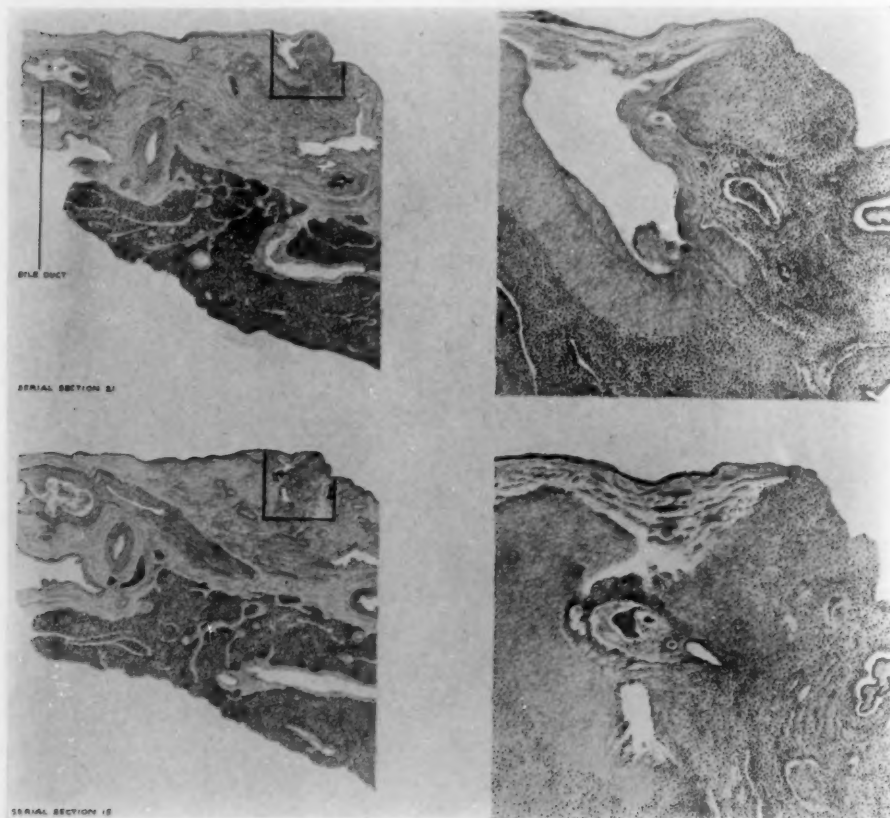
FIG. 4.—Microscopic sections of the point of rupture. Necrotic membrane covers the ruptured duct at the liver surface.

and short, differing from earlier attacks of obstructive jaundice chiefly in its fulminating character. The elevation of the pulse and the prostration are striking, and out of all proportion to the rise in temperature. Abdominal tenderness, generally on the right side, and marked distention are noted. Signs of free fluid have not often been obtained. Jaundice of variable degree is mentioned. Occasionally acholic stools are passed, but more often, with the distention, there is obstinate constipation. Twice, sugar has been found in the urine.

Anatomically, there is evidence in every case of intermittent or constant obstruction of the biliary system over a considerable period of time. The

ducts are dilated, and the gall-bladder dilated, or else scarred and contracted. Gall-stones have always been present, serving as a cause of obstruction with the exception of two instances of malignant disease. The liver has appeared atrophic in one or both lobes. Cholangeitic abscesses have never been found in the organ at large, although jaundice of the liver and chronic and acute cholangeitis prove to be a prominent part of the microscopic picture. The point of rupture lies in a scarred area of the liver surface. Ectatic ducts, that look like minute cysts, project beneath the capsule of Glisson, in the
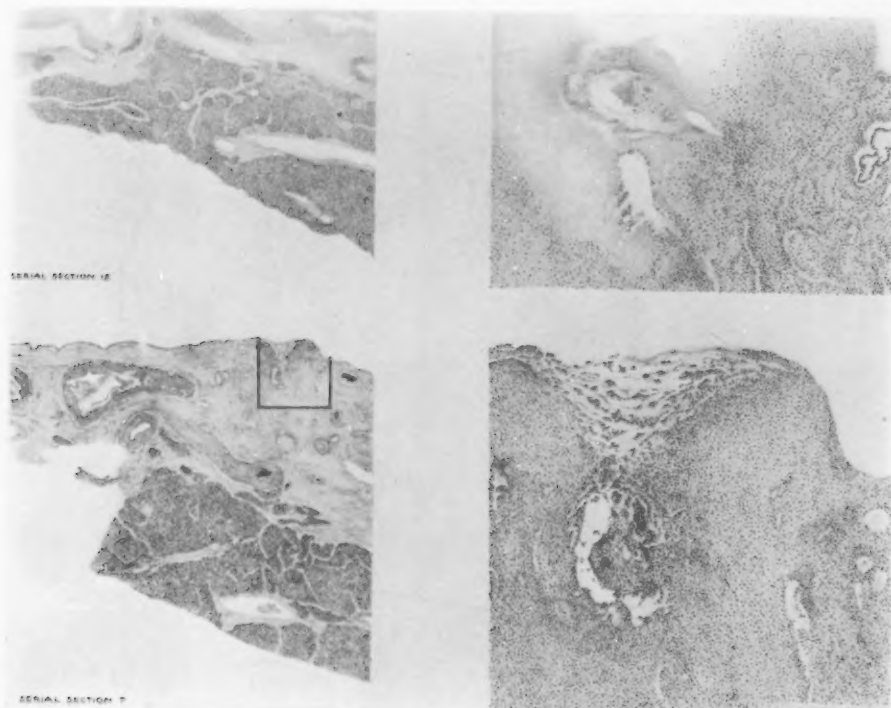
FIG. 5.—Microscopic sections of the point of rupture. Toward one slope of the papilla is found a miliary abcess.

experience of most observers. Usually, the perforation occurs in the left lobe of the liver, or on the anterior surface of the right lobe, over the gall-bladder fossa.

The peritoneal exudate has varied from a small quantity of fluid to 1200 c.c. Bacteriological findings (culture or microscopic examination of tissue or smears) are mentioned seven times: B. coli (3), B. coli and streptococcus (3) and streptococcus (1).

Of the reported cases, that of Levin is so exceptional as to deserve a more detailed description. Rupture of the biliary channels of the liver was unassociated with biliary tract infection, but resulted from obstruction of the extrahepatic ducts by the growth of a gastric carcinoma. Consequent to perforation, a pocket of sterile bile collected and became encapsulated in the peritoneal fossæ about the liver. The collection of bile may have been

TABLE I.

Authors	Sex and age	Past history	Final illness Clinical picture	Duration and result	Cause of obstruction to the biliary system	Biliary tract pathology	Bacteriology	Point of perforation of intrahepatic duct	Peritoneal exudate quantity and character
"Older literature" (Rosenthal–1911)				Fatal probably	Choledochus stricture probably of calculous origin	Dilated intrahepatic ducts markedly distended with bile		Edge of liver	Purulent.
Kolisko–1913 "Eine Reihe von Fällen"					Gall-stones			More often in the left lobe	
Nauwerck–1905 Also by Karrillon–1909 Case 1	Female 49	Negative for jaundice or colic	Sudden onset. Jaundice, thirst, vomiting. No bowel movements. Abdominal pain and distention. Resistance on right side. Elevated pulse and temperature. Finally, light colored stools	4 days — Fatal	Stone in the ampulla of Vater	Gall-bladder dilated. Left lobe of liver atrophic, with biliary cirrhosis. Stones in left hepatic duct. Liver ducts generally dilated and thickened, especially in the left lobe. These ducts often form ampullae as large as a hemp seed on the liver surface, covered only by a thin membrane	B. coli Streptococci	Bridge of tissue between left and quadrate lobes, over the round ligament	550 c.c. of ropy, brownish-yellow to greenish fluid. Cloudy, containing flakes of fibrin.
Nauwerck–1905 Also by Karrillon–1909 Case 2	Female 60	Years of painful abdominal attacks with jaundice	Moribund when seen	Fatal	Stone in the ampulla of Vater	Gall-bladder small and fibrotic, with an ulcer of the neck. Liver enlarged, but left lobe is atrophic, with biliary cirrhosis. Stones in ducts of left lobe. Ectatic ducts of surface of left lobe visible grossly. Duodenal papilla projects due to distention and stone	B. coli	Posterior angle of left lobe	500 c.c. of ropy, brownish fluid strongly positive for bile. Plastic peritonitis as well.
Karrillon–1909 Case 3	Male 66	Negative for the biliary system. Chronic mitral and aortic endocarditis	Sudden onset, patient senile and cachectic. Light jaundice. Vomiting. Cardiac irregularity, coarse râles in lungs. Abdominal distention and resistance. No feces even after enemata. Enterostomy performed on 3rd day	6 days — Fatal	Stone impacted in common bile duct.	Gall-bladder dilated. Liver jaundiced but not cirrhotic except for scarring of surface of left lobe. Left intrahepatic ducts especially dilated. Pus in ducts, and polymorphonuclear infiltration of ectatic ducts of liver surface	B. coli Streptococci	Anterior margin of left lobe	Small amount of yellowish-brown fluid (previously drained by laparotomy). Plastic peritonitis.

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	Sex Age	Previous history	Clinical course	Duration / Result	Diagnosis	Pathological findings	Bacteriology	Location of rupture	Peritoneal fluid
Karrilon-1909 Case 4	Female 59	For one year, frequent attacks of vomiting and jaundice	Probable acute onset. Patient cachectic and markedly jaundiced when seen. Abdominal distention and epigastric tenderness. Fibrinous pleurisy. Trace of sugar in the urine	About 4 days / Fatal	Gall-bladder carcinoma enveloping hepatic duct	Carcinoma of gall-bladder with metastases to regional lymph-nodes and liver. Small gall-stones above obstruction of hepatic duct by tumor. Liver ducts dilated and thickened. Cherry-stone-sized cystic ducts of anterior and posterior surface of left lobe. At point of rupture alone polymorphonuclear infiltration suggests cholangeitic abscess	Strepto-cocci and Diplococci	1. Anterior surface of left lobe. 2. Posterior surface of left lobe	75 c.c. of cloudy yellow fluid. Peritoneal surfaces little altered.
Rosenthal-1911	Female 49	Three months before, an illness of several days with copious vomiting. General health good	Sudden onset. Severe epigastric pain for one day. Five days later showed jaundice, abdominal distention, and tenderness in right hypochondrium. Liver enlarged. Acholic stool. On 7th day an acute attack of abdominal pain with increasing distention. Laparotomy	7 days / Cured	Common duct stones	Gall-bladder contracted and contained stones. Anterior surface of liver over the gall-bladder wrinkled. Cystic ducts visible here, pea-sized. Common bile duct widely dilated and contained numerous stones		Anterior surface of right lobe over gall-bladder fossa	500 c.c. of thick cloudy bile. Intestinal surfaces reddened and glued together.
Nauwerck and Leubke-1913	Female 73			Fatal	Common duct stones	Gall-bladder distended and contained stones. Perforation of dilated subserous bile duct of the liver		Upper surface of the right lobe	1200 c.c. of practically pure bile. Fibrinous peritonitis.
Vogel-1913	Female 72		Several days of intense pain in upper right abdomen with obstipation. On admission to hospital, jaundice, cardiac arrythmia, distended abdomen, tender especially on the right. Tumor palpable in gall-bladder region. Sudden collapse after 5 days in hospital with disappearance of the tumor	8 (?) days / Fatal	Not definitely determined. Probably gall-stones	Gall-bladder showed inflammatory changes, was flaccid, and contained many stones. Left lobe of liver atrophic		Under surface of left lobe	Diffuse bile peritonitis, with fibrinous deposits.
Erner-1915 Case 1	Female 68		Cachexia, icterus. Palpable nodular liver. Vomiting before death	4 days / Fatal	Adenocarcinoma of common bile duct	Gall-bladder tense and filled with stones. Neoplastic invasion of anterior gall-bladder wall and liver. Schnurfurche of the enlarged liver, in which an ectatic subserous duct had ruptured	B. coli	Anterior surface of right lobe	Generous amount of dark greenish brown fluid. Fibrinous peritonitis.

Table I.—*Continued*

Authors	Sex and age	Past history	Final illness Clinical picture	Duration and result	Causes of obstruction to the biliary system	Biliary tract pathology	Bacteriology	Point of perforation of intrahepatic duct	Peritoneal exudate quantity and character
Ermer–1915 Case 2	Female 73	For four years attacks of abdominal pain with vomiting. Recovery rapid. Jaundice in attack ten days before final illness	Six days of pain in liver region. The patient collapsed after an acute attack of epigastric pain following descent of a flight of stairs. Bronchopneumonia also noted	6 days or a few hours. Fatal	Stone in the ampulla of Vater	Gall-bladder shows scars of mucosa and contains stones. Whitened area of surface of the right lobe of the liver. Parenchyma jaundiced. Ectatic ducts of liver surface visible grossly	B. coli	Anterior surface of right lobe over gallbladder fossa	500 c.c. of bile-stained cloudy exudate. Slight fibrinous peritonitis generally.
Present Report 1913	Female 83	For five years attacks of abdominal pain with jaundice. Average of 2 days duration	Sudden onset, abdominal pain and jaundice, like previous attacks. Disappearance of jaundice by third day. Abdominal distention, obstipation. Cardiac arrythmia. Glycosuria and acetonuria	4 days Fatal	Stone in the ampulla of Vater	Gall-bladder moderately large, covered by adhesions, containing stones. Extrahepatic ducts dilated; duodenal papilla projects. Liver jaundiced and atrophic. Chronic and acute cholangeitis without abscesses. Scarred area over gall-bladder fossa	Streptococci	Anterior surface of right lobe over gallbladder fossa	150 c.c. of green cloudy fluid. Reddening of intestinal surface. Small amount of fibrin.
Levin–1913	Female	Negative past history until the last year. Illness marked by pain after eating and occasional vomiting	Cachexia. Eight weeks of epigastric pain. Nodular liver, palpable together with epigastric mass. Jaundice	Fatal	Gastric carcinoma compressing the common duct	Extensive abdominal carcinomatosis, primary in pyloric region of the stomach. No disease of the biliary tract made out. Liver ducts dilated and parenchyma intensely jaundiced. Microscopically no cholangeitis	Presumably sterile	Posterior surface of right lobe	"Cholocele" Encapsulated effusion of clear bile. Quantity— 2000 c.c.

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present for a considerable time before death, and was a purely incidental finding at autopsy.

Other reported cases of intrahepatic bile duct rupture fall into a single group, the outstanding feature of which is an antecedent biliary tract infection followed by a peritoneal infection of high virulence. Rosenthal has recorded the only instance of cure by surgical means.

Bile Peritonitis.—Bile peritonitis occurs under various conditions, among which must be included lacerations of the biliary tract through incised wounds of the abdomen, contusions of the abdomen with or without previous disease of the liver and larger bile channels,* and, finally, both acute and chronic inflammations of the bile channels with and without obstruction. The present communication deals primarily with peritonitis associated with the escape of infected bile from ruptured intrahepatic bile ducts in instances of obstruction to the larger bile ducts. For clarity, however, reference will be made to rupture of extrahepatic bile channels under similar conditions. Finally the so-called examples of unexplained bile peritonitis, where no exit for the bile from the biliary system is said to occur, will be discussed.

McWilliams (1912) collected 108 reports of operations where spontaneous perforation of the gall-bladder or extrahepatic ducts had occurred. In all, peritonitis was associated with perforation of the biliary tract, the seat of previous and long-standing inflammatory disease. This finding is important because it is at variance with the usual result in infections of the gall-bladder, namely local adhesions with, at most, circumscribed abscess formation. In a total of 3180 operations on the biliary tract reviewed by McWilliams perforation was encountered twenty-nine times, 0.9 per cent. Comparable figures were obtained by Karrillon from analysis of 6114 consecutive autopsies. He found gall-stones 572 times, and in seven instances there was associated perforation of the gall-bladder or duct, 1.2 per cent. Karrillon's findings are a notable exception to the generally accepted idea, that the gall-bladder is the most common site of perforation. He records three gall-bladder perforations, four perforations of intrahepatic ducts, and none of extrahepatic ducts.

. From the above analysis it would seem that perforation of some portion of the biliary system into the peritoneal cavity occurs roughly once in every 100 cases of infection of the tract, when there is obstruction to the outflow of bile. However, the experience of individual surgeons and pathologists has varied tremendously in this respect, and the impression gained from the ordinary surgical text-books tends to minimize the possibility in the mind of the reader. Further, perforations of the gall-bladder are alone considered in detail, even in so comprehensive a work as Rolleston's (Diseases of the Liver, Gall-bladder, and Bile Ducts).

There has arisen in the past fourteen years a concept of bile peritonitis without rupture of the biliary tract. Between sixty and seventy cases of the

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* For detailed information concerning the type of the disease, reference is made to Kehr (Chirurgie der Gallenwege).

sort have been reported on the basis of operative or autopsy findings, and the question of filtration of bile through an unbroken gall-bladder wall has been considered by a number of observers. To confirm or overthrow this hypothesis some experimental work has been done, while the field has been reviewed repeatedly of late, notably by Buchanan (1918), Ritter (1921), Wagner (1922), and Burckhardt (1923).

Seventy-three cases are mentioned in Burckhardt's paper, including a few obscure but verified perforations, as well as a few instances in which the biliary character of the peritoneal effusion was doubtful. The relatively large number of cases is striking as contrasted with the scarcity of reports on spontaneous perforation of the cystic, hepatic, and common bile ducts, of which there are probably not more than twenty in the available literature, including the eight which McWilliams has collected.

In the great majority of the cases of unexplained bile peritonitis the operator or the pathologist was convinced that the peritoneal cavity contained bile, although no point of escape from the gall-bladder or bile ducts could be found. Noteworthy pathological changes of the biliary tract were always present. The peritoneal exudate varied in character and amount, as did the severity of the peritonitis. The various theories that have been offered to explain the phenomenon fall into two main groups. First, is the belief that diffusion of bile salts through a gall-bladder wall may take place in gangrenous cholecystitis, so that a peritoneal exudate is stained brown or green. *The question may well be raised whether the mere presence of bile pigments in a peritoneal exudate is germane to the subject under discussion. It is the belief of the writer that bile peritonitis should be defined as an inflammatory reaction of the peritoneum caused by infected bile.* Second, that a perforative lesion of the biliary tract has been overlooked. This may be a microscopic or minute macroscopic rent in the walls of the gall-bladder or bile ducts; or it may be a small perforation which has subsequently healed or become covered with plastic exudate. A study of the accumulated literature at first hand brings the strong conviction that no single mechanism will explain all instances. Nevertheless, in cases of bile peritonitis of obscure origin, the bile ducts of the liver surface must always be considered as possible points of perforation.

Pathogenesis of Intrahepatic Bile Duct Rupture.—Although rupture of intrahepatic bile ducts is apparently rare, scars of the liver surface containing dilated bile ducts are common. Under conditions of infection and obstruction these conceivably may rupture and allow infected bile to escape into the peritoneal cavity. In fact, Karrillon and Ermer reached this decision after detailed histological study. These observers differ, however, in the interpretation of the mechanism concerned with the actual rupture. Karrillon assumes a critical moment of high pressure which leads to dehiscence of the walls of the ectatic duct, while Ermer is inclined to believe that the duct does not burst

acutely but that the rupture is brought about by pressure necrosis acting from within the duct upon a poorly vascularized scar.

From the facts gathered by study of the instance herewith reported, it is believed that the mechanism of rupture is explicable on the following basis. Chronic inflammation of the biliary channels with gall-stones had existed for several years. An exacerbation of the inflammatory process involved a group of ectatic bile ducts in a small scar beneath the liver capsule. Necrosis with rupture was a natural consequence.

SUMMARY

1. In the course of chronic and acute cholangeitis with obstruction to the hepatic or common bile ducts, perforation of a bile duct of the liver surface may occur.

2. The incidence of such perforations is probably higher than reports indicate. This fact may have a bearing on the reports of bile peritonitis without macroscopic perforation of the biliary tract.

3. The perforated liver duct is often dilated and is found in a scarred area of the liver surface where the liver parenchyma has been replaced by fibrous tissue.

4. The cause of perforation is the formation of a miliary cholangeitic abscess near an ectatic bile duct, in a superficial scar of the liver.

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THE MECHANISM OF INTESTINAL PERFORATION DUE TO DISTENTION*

By Frederick T. van Beuren, Jr., M.D.

of New York, N. Y.

Intestinal perforation following prolonged over-distention is quite a different entity from perforation resulting from an intestinal ulcer. It is of much less common occurrence, and appears, so far as I have observed, only in cases of mechanical ileus. The perforation in such cases is generally situated upon the antimesenteric surface of the intestine, usually quite close to the point of obstruction. It is surrounded by an area of discoloration generally diamond-shaped or of an irregular shape resulting from the coalescence of two or more diamond-shaped areas. These diamond shapes correspond roughly to the terminal anastomotic tree of the intestinal vessels and are evidently the result of hemorrhage from these vessels; that is, hemorrhagic infarct of the area supplied. The mech-

Fig. 1.—S. P. No. 7489. Intestine obstructed 144 hours. Small hemorrhagic areas in region of terminal intestinal vessels.

Fig. 2.—S P No. 5882. Intestine obstructed 72 hours. Diamond-shaped infarct on antimesenteric surface with section out for microscopic examination.

anism of this infarction appears to be as follows: Distention of the intestine increases its diameter. Any increase in its diameter is tripled in its circumferential measurement. In other words, if the diameter of an intestine is increased by distention from 1 cm. to 3 cm., its circumference is at the same time increased from 3 cm. to 9 cm. Thus, the difference in the diameter is only 2 cm., while the difference in the circumference is 6 cm. A moderate increase in diameter, therefore, results in considerable stretching of the wall. The intestinal vessels pass between the layers of the wall along its circumference from their origin at the mesenteric border to their terminal anastomoses at the antimesenteric surface, becoming progressively more thin-

* Read before the Southern Surgical Association, December 12, 1923.

walled and more narrow of lumen. Because they are elastic the stretching of the intestinal wall from distention still further thins the vessel walls and narrows the vessel's lumen like a stretched rubber tube. At the same time the pressure from within the intestine tends to flatten out the vessel's lumen.

The narrowing of the vessel's lumen and the thinning of the vascular wall are maximum at the antimesenteric surface of the intestine where the terminal anastomoses occur; and, the distention pressure being constant throughout the lumen of the intestine, the maximum effect is seen at the antimesenteric surface where a union of the three factors of pressure, thin wall and narrow lumen finally results in obliteration of the vessel. This obliteration occurs sooner in the vein than in the artery on account of the less resistant wall. The blood continues to pour through the arterial vessel until the pressure against the obliterated vein suffices to rupture the vessel

FIG. 3.—S. P. No. 7471. Intestine obstructed 77 hours. Multiple infarcts on antimesenteric surface.

FIG. 4.—S. P. No. 7471. Mesenteric surface of same specimen as Fig. 3. Absence of infarcts near mesentery.

wall and permit extravasation and coagulation. Finally, the pressure occludes the artery as well as the vein. The area of tissue supplied by these terminal vessels is thus deprived of circulating blood and necrosis occurs. This necrosis is usually first evident in the submucosa and inner muscular coat, but rapidly extends to the other coats of the intestinal wall, and perforation

may occur within twenty-four hours after the discoloration due to the hemorrhagic infarct has been first noticed.

It will be noted that hemorrhagic infarcts and perforations resulting from their necrosis cannot be expected to occur at any regular interval after obstruction, because the degree of distention varies so much in the individual cases and the infarction appears to depend entirely upon distention sufficiently prolonged and in excess of the normal limit.

FIG. 5.—S. P. No. 5946. Intestine obstructed 180 hours. Coalescence of necrotic hemorrhagic infarcts into gangrenous area on antimesenteric aspect just above point of obstruction.

The first twelve illustrations are of material from dogs operated upon in the laboratories of the Department of Surgery, College of Physicians and Surgeons, Columbia University. The last four are from a clinical case operated upon at the Presbyterian Hospital.

FIG. 6.—S. P. No. 7483. Intestine obstructed 120 hours. Perforation due to necrosis of hemorrhagic infarcts on antimesenteric surface.

Figure 1 shows an intestine that had been obstructed 144 hours. Several small hemorrhagic areas can be seen in the region of the terminal intestinal vessels.

Figure 2 shows quite distinctly the usual diamond-shaped form of the hemorrhagic infarct from which, in this instance, a section has been removed for microscopic examination. This intestine was obstructed for 72 hours.

Figure 3 shows multiple hemorrhagic infarcts in an intestine that had been obstructed only 77 hours. This specimen shows excellently their situation along the antimesenteric surface, while

Figure 4 shows the mesenteric border of the same specimen of intestine exhibiting no hemorrhagic areas near the mesenteric border.

Figure 5 shows a further development of multiple hemorrhagic infarcts three of which have coalesced to form an irregular discolored area on the antimesenteric surface near the blind end of the oral segment of the intestine. This specimen was taken from an intestine obstructed for about 180 hours.

Figure 6 shows a perforation near the blind end of the oral segment of an intestine that had been obstructed about 120 hours. The irregular diamond-shaped area of discoloration (which was very evident in the fresh specimen) around the perforation does not show distinctly in the photograph.

Figure 7 shows an interesting comparison of the pressure effects on thinning the intestinal wall, the two upper specimens having been obstructed only 48 hours, the two middle ones for 72 hours, the next to the lowest for about 96 hours, and the lowest for 180 hours.

Figure 8 shows how the beginning of infarction probably appears microscopically w h e r e congested, thrombosed vessels are seen in the submucosa of an intestine obstructed for 72 hours.

Figure 9.—Extravasation has occurred from over-filled blood-vessels, both in the submucosa and in the muscular coat.

In Figure 10 the extravasation has increased in size, and the pressure is presumably greater.

In Figure 11 necrosis is well-advanced, and the integrity of the wall is gravely threatened.
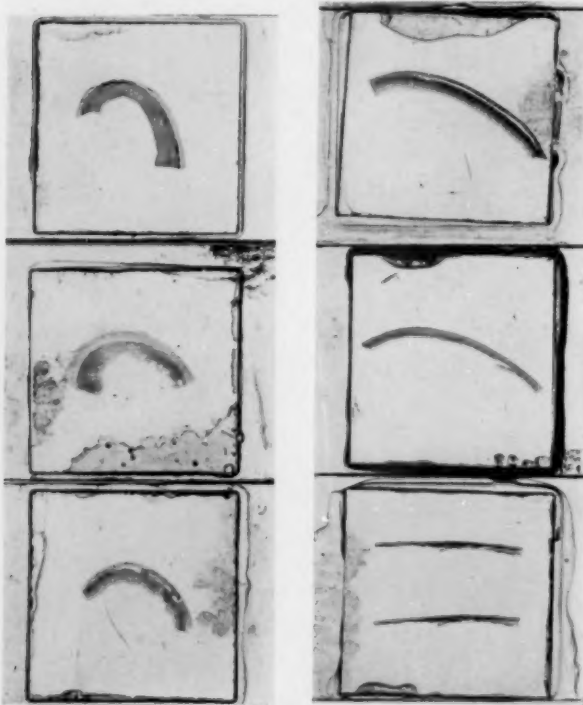

FIG. 7.—S. P. Nos. 5922, 5935, 5882, 5883, 5944, 5946. Intestines obstructed from 48 hours to 180 hours. Progressive stretching and thinning of intestine due to distention.

In Figure 12 the completely necrotic area of the perforation is shown.

Figure 13.—Serous surface of human intestine obstructed about 130 hours. Hemorrhagic infarcts may be seen at A, B and C.

Figure 14.—Same intestine photographed by transmitted light (somewhat similar to a radiograph). Hemorrhagic infarcts at A, B and C.

Figure 15.—Low power photomicrograph of section of same showing scattered submucous hemorrhages.

Figure 16.—Same showing single large submucous hemorrhage.

The last four figures are taken from the human case whose history follows: (I am indebted to Dr. F. B. St. John for the opportunity of reporting it.)

CASE I.—S. W., a woman of thirty-eight years, came to the Presbyterian Hospital on the night of October 2, 1923, with a history of abdominal pain which had begun seventy-two hours before and had shortly been followed by nausea and vomiting. The pain, though varying in intensity and moving from upper to lower abdomen, had persisted,

and the vomiting had been repeated several times each day but had not assumed a fecal character. Her bowels had moved on day of onset but not since. A cathartic taken the day before admission had been promptly vomited, and an enema given on the day of admission had returned practically unchanged. She was worried by the fact that she had passed no flatus, but she complained of no undue abdominal distention. The only relevant items of her past history were an appendicectomy, four years previous, and an

FIG. 8.—S. P. No. 5922. Intestine obstructed 48 hours. Thrombosed vessels in submucosa.
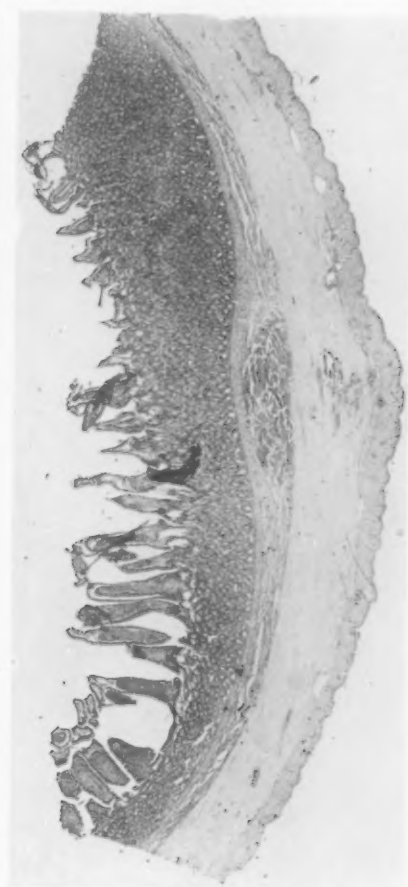
FIG. 9.—S. P. No. 7480. Intestine obstructed about 72 hours. Extravasation in submucosa and muscularis. Beginning of hemorrhagic infarct.

attack of abdominal cramps, nausea and vomiting that lasted twenty-four hours, one year previous to onset of her present illness.

On admission, she was apparently in some pain but did not appear to be very ill. Her pulse, blood pressure, temperature, and respiration, were within normal limits, and her urine was normal. Her white blood count was about 14,000, polymorphonuclears 80 per cent. Heart and lungs negative except for a few râles at left apex posterially. The abdomen was not distended and moved with respiration. Its lower half was rather more prominent than the upper and was less tympanitic on percussion. There was no visible peristalsis and no stiffening of the gut was felt. A small oblique scar in right lower quadrant indicated the old appendicectomy. There was slight tenderness, both direct and release, more marked to left of midline and slight muscle spasm which was thought to

be chiefly voluntary. There was slightly increased discomfort when uterus was moved in pelvic examination. There were no feces in rectum. Otherwise, the physical examination was negative. A diagnosis of partial intestinal obstruction due to adhesion was made, and as she appeared to be in good condition and had recovered spontaneously from her previous attack a year before, palliative treatment by poultices, enemas, colon irrigation, and hypodermoclysis was begun.

During the first 48 hours after admission, 5 out of 6 colon irrigations given, brought away feces and flatus. Her temperature, except for one observation, remained below 100° F., her pulse below 90, her respiration below 20. Her white blood count fell to 9,000, polymorphonuclears 61 per cent. She vomited several times, however, her abdomen became distended, her urine showed a trace of albumen; her blood urea was found to be quite high and her general condition looked less favorable. On the morning of the third day (almost 60 hours after admission and 130 hours after onset) Dr. Barclay Parsons operated under ether anæsthesia. Upon entering the peritoneal cavity, greatly
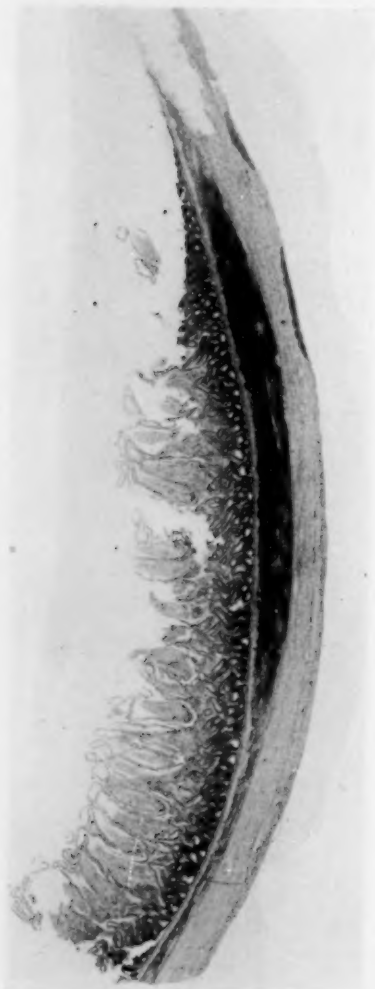
FIG. 10.—S. P. No. 7471. Microscopic section from specimen shown in Fig. 3. Large extravasation. Wall much thinned by pressure.
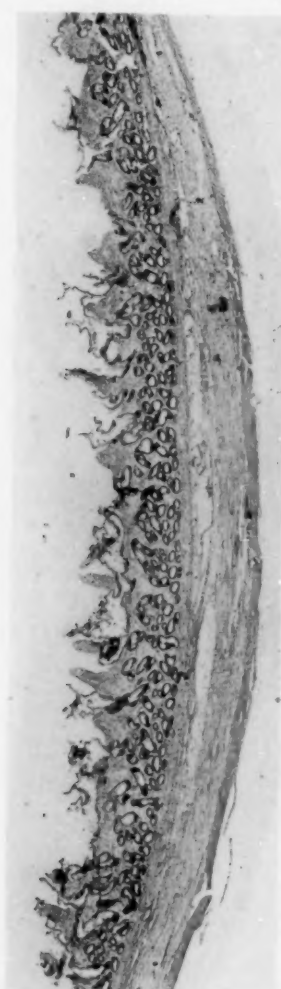
FIG. 11.—S. P. No. 7489. Microscopic section of specimen shown in Fig. 1. Advancing necrosis of infarcted areas.

distended injected loops of swollen intestines presented. There was no free fluid. In the right lower quadrant there was a broad band of adhesions extending upward from the cæcum and terminal ileum to the anterior abdominal wall just below the old scar. There was no evidence of kinking here, and no constriction of the intestines. Upon exploring the ileo-cæcal region, however, the intestines were found to be bound down as if by internal herniation behind in the ileo-cæcal fossa. Manipulation freed the loop, which presented a constriction proximal to which the gut was greatly distended, reddened, and of paper-thin consistency. Distal to the constriction, the gut was collapsed, but the great discrep-

ancy in diameter diminished rapidly while the loop was being examined. While exploring the intestine a fecal odor was noticed, and fecal contents were discovered leaking from an opening in the distended gut. This opening was about 1 cm. in diameter, resembled a tear rather than an ulceration, and was situated about half way between mesentery border and antimesenteric surface. The mesentery in this region was very much injected

FIG. 12.—S. P. No. 7483. Microscopic section of specimen shown in Fig. 6. Completely necrotic edge of perforation.

FIG. 13.—P. H. Autopsy No. 9426. Hemorrhagic infarcts at A, B and C on antimesenteric aspect of intestine which has been split open along its mesenteric attachment.

and somewhat thickened, but there were no noticeably enlarged lymph-nodes. A short distance away, the serosa of the gut split for a distance of 2 cm. merely when pressure was exerted upon an adjacent loop. There was no pathology noted other than the distended, congested, friable intestine above the point of obstruction, and the collapsed intestine distal to it.

The split serosa was repaired, the rim of the perforation in the intestine excised, and the aperature closed. An enterostomy was made and the wound closed with drainage.

Microscopic examination of the specimen excised showed that the mucosa was intact in many places. In other places the epithelium was absent, and both mucosa and submucosa showed hemorrhage. The submucosa and muscularis were œdematous and in places showed degeneration and hemorrhage, and all layers were infiltrated with
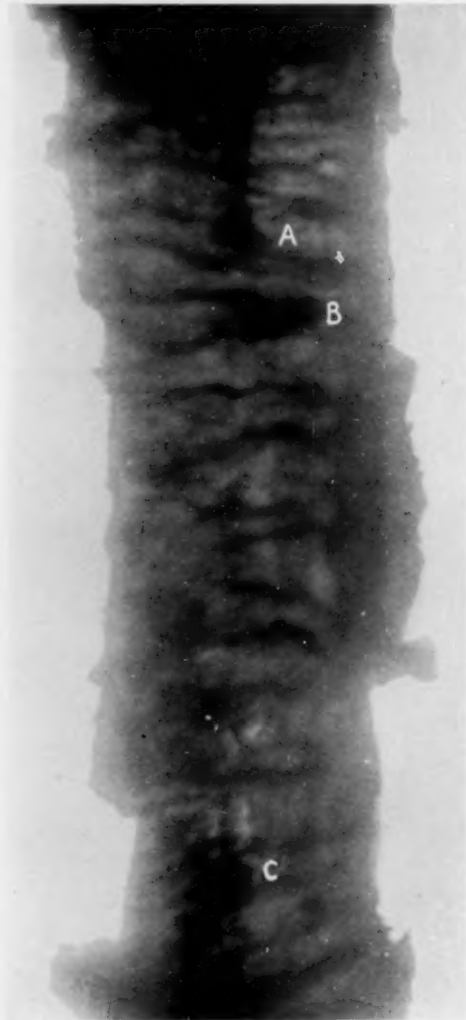
FIG. 14.—Same specimen as in Fig. 13, showing infarcts by transmitted light at A, B and C.
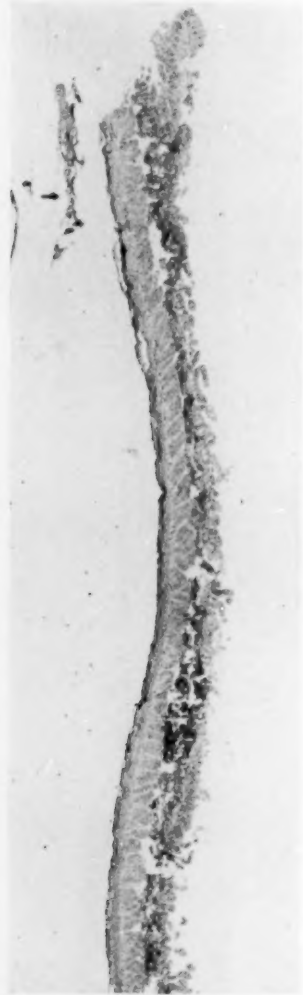
FIG. 15.—P. H. Autopsy No 9426. Low power of intestine showing very small hemorrhagic infarcts in submucosa.

leukocytes. The patient died about five hours after operation, with signs of acute respiratory and cardiac failure.

At autopsy, a pulmonary embolus was found and the intestine showed the striking changes due to over-distention resulting in hemorrhagic infarction. One of the areas of infarction had presumably necrosed to the point of perforation, but it was not definitely determined whether perforation had been spontaneous or had been induced by the necessary handling of the gut in freeing the obstructed portion.

The peritoneal cavity contained an excess of thin, bloody fluid most abundant in the pelvis. The omentum lay for the most part in the right half of the abdomen. Where

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the loops of small intestine are exposed they are lightly bound to the parietal peritoneum by a thin fibrinous exudate. The small intestine is moderately distended with gas; the surfaces are covered with thin fibrinous layer of exudate. The vessels in places are injected and there are occasional small fresh hemorrhages beneath the serosa. The transverse colon is somewhat distended. The stomach extends over to the costal margin at the right mid-axillary line and completely hides the lower border of the liver.

Gastro-intestinal Tract:—The *stomach* is negative except for post-mortem erosion. The *duodenum* is negative. There are no hemorrhages beneath the mucosa or serosa. It appears normal in every respect. The *intestine:* the serosa of the small gut is covered with fibrinous exudate, and in places the exudate is fibrino-purulent. Beneath the serosa, particularly in the first part of the jejunum, one sees dark areas which are apparently hemorrhagic and which, in general, follow around the circumference of the gut. At one point 135 cm. from the beginning of the jejunum, there is an enterostomy wound with the tube sutured into the gut. It was this tube that passed out through the omentum. Twenty-five cm. above this tube a line of sutures in the gut runs parallel to the mesenteric attachment, and here there appears to have been an opening extending directly into the lumen (probably the perforation noted at operation). There is no change made out around this area except hemorrhages beneath the margin of the mucosa. In the first part of the jejunum the mucosa appears normal except for occasional small hemorrhages lying beneath it. As one passes down the mucosa there is no exudate seen on its surface;

FIG. 16.—P. H. Autopsy No. 9426. Low power of intestine showing larger submucous hemorrhage.

it has rather a velvety appearance. In a few places the crests of the rugæ appear injected, and this injection is particularly marked where the enterostomy tube was inserted. Here the submucosa is rather hemorrhagic, but the mucosa seems to be intact, and no exudate is made out. Extensive hemorrhage is seen beneath the mucosa about 25 cm. beyond the enterostomy opening, but there is no exudate seen on this part. In the ileum there is seen beneath the serosa a narrow, hemorrhagic band about ¾ mm. wide, which entirely encircles the gut. The serosa is roughened over this area, as if there had been an adhesion (this was point of obstruction). Within the gut, the mucosa directly

overlying this band has disappeared and there is a grayish exudate encircling the gut which corresponds exactly to the outline of the hemorrhagic band seen beneath serosa. This ulceration is seen 100 cm. below the enterostomy opening, or 235 cm. from beginning of jejunum and 200 cm. from ileo-cæcal valve. The vessels in the mesentery at the site where this encircling ulceration of the intestine occurs do not seem to be thrombosed. It passes through a large Peyer's plaque. The gut below this area is quite dark red in color. The mucosa is quite purplish but seems intact. The Peyer's patches and solitary follicles stand out very sharply. Just at the margin of the ileo-cæcal valve is an area which appears to be slightly ulcerated, but this cannot be definitely determined. This area is only about 1 cm. in greatest diameter. The mesentery of the small intestine, especially that portion going to the ileum, is covered with fibrinous exudate. There are numerous recent hemorrhages beneath the peritoneum, and in the smaller veins are dark red thrombi.

THE ILIO-HYPOGASTRIC NERVE IN RELATION TO HERNIOTOMY

By Edmund Andrews, M.D.

of Chicago, Ill.

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY OF ILLINOIS

The relation of the nerves in the inguinal region to the innervation of the lower abdominal muscles has been the subject of much discussion. The importance of the matter is evident on account of the frequent lesions of one or more of them in the performance of inguinal herniotomy. The ones liable to injury are the ilio-inguinal and the ilio-hypogastric. The arrangement of these is exceedingly variable. Both arise from the first lumbar, often in a common trunk, and both generally receive fibres from the twelfth dorsal. The nerves pierce the internal oblique muscle very close together a short distance above and lateral to the inguinal canal. The ilio-inguinal becomes incorporated in the cord and emerges with it through the external ring to supply the skin of the scrotum in part together with a patch on the thigh. About this nerve there can be no question. In the inguinal canal where it is liable to injury, it is purely sensory. Its motor fibres are given off before it enters the surgical field.

The ilio-hypogastric presents a more difficult problem. Its hypogastric branch as we see it at operation runs between the internal and external oblique one or two cm. from the lower border of the former. It is generally described as lying on the internal oblique, but this is not strictly correct as it is often more intimately associated with the external oblique aponeurosis, and when the two are separated the nerve often comes up with the outer layer. It pierces the aponeurosis just above the internal ring and supplies a rather variable skin area there. In cases where it has been sectioned at operation, it is generally impossible to outline any area of anæsthesia, as the overlap of the twelfth dorsal and the ilio-inguinal fields is so great. Paræsthesia is more common. Anastomosis between these two nerves is free throughout their course, and the relative size of the two is variable. It is not at all uncommon to find one very large and the other very minute. Often only one can be demonstrated and it runs a course very close to the lower border of the conjoined tendon.

The important question is whether any motor fibres are given off from this nerve in the inguinal canal. The anatomical texts unanimously beg the question. Judging by the anatomical arrangement and the close proximity of the ilio-hypogastric to the internal oblique the entire length of the canal, it would seem logical to assume that some of its motor fibres were given off in the canal and that section during operations would therefore cause a paralysis of its lower fibres. These, of course, are the all-important ones in

relation to the cure of hernia, and the preservation of this nerve would seem vital.

Dowd [1] stimulated the nerve during the course of operations and caused contractions of the lower fibres of the external oblique. He assumed that this meant that motor fibres were given off below the point of stimulation. This, of course, was an unwarranted assumption as the possibility that the response was reflex was not considered.

Subsequently, Moschcowitz [2] sectioned the anterior roots to this nerve in two dogs, and after allowing time for descending degeneration to occur, killed the dogs and failed to find any signs of degeneration in the nerves in the inguinal canal. This experiment doubtless settled the matter as far as dogs were concerned, but in view of the great differences in the anatomy of the inguinal region in the dog and man, could not be said to mean much for the latter. In dogs there is no conjoined tendon. The lower fibres of the external oblique are absent and it inserts high up on the rectus sheath. The very fibres under question in man are not found in the dog.

However, I wish to report some experiments which confirm the latter view, that the nerve in the canal is purely sensory. In two cases I have stimulated both ends of a nerve which had already been accidentally sectioned at operation. Incidentally, I would like to say that injury to these nerves is most often due to the pernicious teaching of pushing a director up the canal and cutting onto it to lay the canal open. If the director slips under the nerve, as often happens, it is almost sure to be cut. In both of these cases electrical stimulation of the distal segment gave no contraction, but stimulation of the proximal segment caused violent contractions of the lowest fibres. This, of course, can only be interpreted as a reflex action.

As in each of these cases the section of the nerve had been made in the middle of the canal, the results held good for only the proximal portion. Therefore the question was put to the test in the following manner. During operation under general anæsthesia, the nerve was dissected free at the uppermost end of the canal. Here it was blocked in a short section by the injection of a little 2 per cent. novocain under its sheath. Sterile electrodes were then applied just distal to the point blocked and no reaction to stimuli could be produced. If, however, the electrodes were applied proximal to the infiltrated area, stimulation produced contractions of the internal oblique fibres visible in the canal. This experiment was repeated on five individuals with seven hernias, and in all cases the results were the same.

Conclusions.—The only possible interpretation of these experiments is that the ilio-hypogastric nerve is motor to the lower fibres of the internal oblique muscle, but that all the motor fibres are given off before the nerve enters the field of operation for hernia, and that, therefore, accidental section of this nerve will not cause any paralysis of this muscle.

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[1] ANNALS OF SURGERY, vol. lxi, p. 483.
[2] Moschcowitz: ANNALS OF SURGERY, vol. lxvi, p. 79.

MULTIPLE SACS IN INGUINAL HERNIA
By Andrew McQueeney, M.D.
of Bridgeport, Conn.

The area known as the fovea inguinal internus, *i.e.*, the portion of the inguinal region between the median line and a fold of fascia in the region of the deep epigastric vessels; is occupied by relatively more preperitoneal fat than any other region except the fatty capsule of the kidney. The preperitoneal fat in the inguinal fovea is continuous with the retro-pubic fat anterior to the bladder. This fact is of peculiar interest to the surgeon. In this region inguinal and femoral herniæ occur and the sac may be covered by this fat and be mistaken for a pad of fat. Here is found a weak, ovoid area bounded below by Cooper's ligament (*i.e.*, the thickened part of the pectineal fascia), externally, by the ilio-pectineal ligament, above, by the free border of the internal oblique muscle and the conjoined tendon, and internally by the arched border of the conjoined tendon (inguinal aponeurotic arch) and the lacunar (Gimbernat's) ligament. This ovoid area is divided into an upper and lower segment by the inguinal (Poupart's) ligament. This place is weaker than any other part of the abdominal wall. The chief retaining membrane is the transversalis fascia which lines the entire abdominal cavity external to the peritoneum. This fascia is normally thicker here than elsewhere.

Below Poupart's ligament at the site of the crural (femoral) ring, the layers external to the peritoneum are the transversalis, cribriform, superficial fascias and skin. Above Poupart's ligament the aponeurosis of the external oblique muscle gives added protection to the peritoneum and transversalis fascia except at the site of the external abdominal ring. In this region 79 per cent. of herniæ of the abdomen occur, *viz.*, indirect and direct inguinal and femoral. (See Fig. 1.)

Hernial sac with fatty capsule was found to be the rule in femoral hernia, and in the majority of direct inguinal herniæ. It was frequently found in association with other hernial sacs on the same side. The finding of this type of sac frequently in so-called recurrent hernia, prompted me to the belief that more than one sac is often present, contrary to present day teaching; but, being mistaken for a pad of fat is not removed.

How many times is a second sac overlooked in the ordinary routine of inguinal hernioplasty? I do not refer to the extra lobule of the bifurcated sac in hernia as described by Hoguet. In this latter type two portions of the same sac are separated by straddling the deep epigastric vessels.

The condition to which I desire to call attention may be described thus. There is found the usual glistening sac or peritoneal protrusion entering the spermatic cord at the site of the internal abdominal ring. In addition there is found, above and external to the pubic spine a thick-walled sac composed of a thin pouch of peritoneum enveloped in a fatty capsule,

varying from $^1/_{16}$ to $^1/_4$ inch in thickness; which is again enveloped in a very delicate membrane derived from the preperitoneal fat.

The old aphorism, "familiarity breeds contempt," is nowhere more often applicable than when dealing with hernia. No operation is more frequently considered beneath the forte of the surgeon. Yet it would seem that we have too readily accepted the classic description as given by Bassini and others and neglected to observe carefully the cases which vary from the classic types. In checking back on cases that have come to a second or third
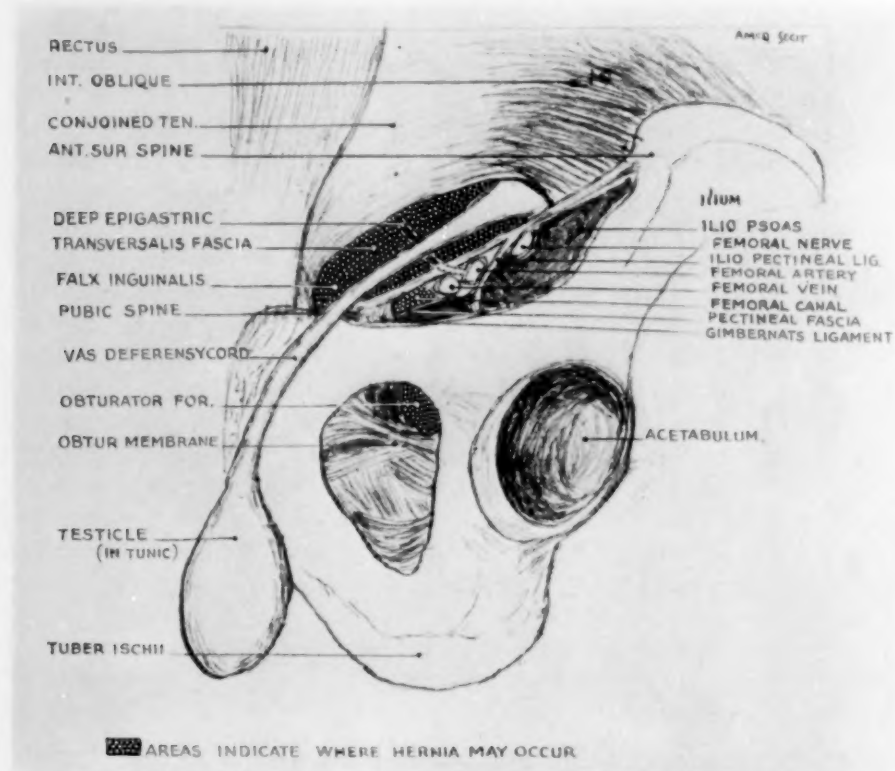
FIG. 1.—The hernia zone.

operation, one is impressed with the fact that although the primary operation was for an indirect variety of hernia; the recurrence is of the direct variety. My contention is that in most cases the two sacs were present at the time of the first operation. Because of the generally accepted teaching, the thin-walled sac was recognized and cared for and the fatty-walled sac overlooked or not recognized for its true status and simply pushed beneath the inner-most sutures, which united the conjoined tendon to Poupart's ligament. In the history of these cases the patient usually says that he felt the same "strain" immediately after operation as before but that the mass did not become appreciable as an external swelling for from one to six months.

The present day argument that the recurrences are due to sewing red

muscle to white fascia and not white to white seems far-fetched. Anyone who has operated for recurrent hernia knows full well that the internal oblique, will, and does heal firmly to Poupart's ligament in the mid-portion of the inguinal canal. It is only at the inner portion above the pubic spine, where the areolar tissue is not properly cleaned from the conjoined tendon that recurrences occur. The importance of the transversalis fascia is often overlooked. I am firm in the belief, that if care is taken, to recognize and excise all sacs or peritoneal protrusions from the inguinal region, to close the rent in the transversalis fascia, and to carefully free the edges of the transversus and internal oblique muscles and tendons and Poupart's ligament of fatty tissue; that the technic of Bassini answers fully as well as any of the numerous later modifications.

Souttar [1] recently called attention to the fatty capsule about the sac in femoral hernia. I believe that careful examination of cases of inguinal hernia will reveal a large per cent. with two sacs; an indirect thin-walled sac and direct fatty sac. During the past four years nine cases with multiple sacs have been noted, out of a total of 129 cases of various kinds of hernia. This is approximately 7 per cent. This per cent. is about the same as is given by honest statisticians as the number of recurrences. Multiple sacs were usually found in fat individuals between thirty-five and fifty years.

Of the total number, 129, the different kinds of hernia were as follows: inguinal 95, (indirect 81 or 63 per cent., direct 14 or 10 per cent.); femoral 8, or 6.2 per cent.; umbilical, 11 or 8 per cent.; recurrent: inguinal 9 (6 direct, 3 indirect) or 6.9 per cent.; abdominal 5 or 4 per cent.; internal 1 or .8 per cent. There were six strangulated herniæ, four inguinal, one femoral and one umbilical. Six were congenital. The strangulated and congenital are otherwise classed according to location.

REFERENCE

[1] Souttar: British Medical Jour., Mar., 1924, p. 367.

DISLOCATION OF THE SHOULDER

By James H. Stevens, M.D.

of Boston, Mass.

There are probably few fields of surgery which have been tilled more intensively than dislocations of the humerus at the shoulder-joint. It would seem as if the last word had been said on this subject and that following the footsteps of Allis and Kocher and Stimson, there would remain few if any new ideas which could be evolved in this old subject. But like many other fields of medicine and surgery it would seem to us that the last word is still a long distance away and that perhaps by an intensive résumé of these old pathological conditions, we may evolve occasionally a new idea which may be of just as much value to the profession as the pursuit of these newer theories, many of which we shall look back upon in later years with tolerant amusement. Most of the old hackneyed subjects will stand a good deal of intensive study, with equal advantage to ourselves, to the profession at large, and to the public. Is there any need for a further study of such a well-known subject as dislocation of the shoulder?

It is difficult to make a patient realize that a dislocation of a shoulder is in reality not a simple matter, and that the effect of such an injury results many times in a permanent loss of power and efficiency to the individual, which can only be reflected in our economic national life, in a loss of productivity when we multiply this individual loss by the number of accidents of this kind. Even the medical profession fails to take seriously a dislocation of the shoulder. What are the facts? Schultz, who can hardly be criticised as an investigator, collected the end results of all dislocations of the shoulder in Kutner's Clinic for five years. There was a total of 160 cases. Some of these cases never returned. Others were excluded because of the complications. There remained fifty-four cases in which there were no complications to the luxation. Late results in these fifty-four cases showed that in only seven was the joint motion free with no pain and no loss of power that was noteworthy and that even in these seven cases, there was a loss of power which was easily measured. In thirty-nine, or 75 per cent. of the cases, there was marked weakness of the arm so as to be noticeable, and in one-half of these, pain was a symptom. These are startling figures and mean either that the trauma is more serious than we have been taught to believe, or that there is something wrong with our treatment. I believe it to be due to a mixture of both, but principally to the fact that in the treatment of dislocation of the shoulder, we have given little consideration to the damage which has been sustained by the supraspinatus and the short posterior rotators and that we have never considered their relaxation as a requisite to their full recovery.

A muscle always has a certain amount of elasticity but it is normally within well-defined limits and these limits are comparatively narrow. A

muscle only recovers its full function after injury if permitted to do so, in the position of relaxation. Unfortunately, Schultz does not tell us how many of these cases presented that most unfortunate feature of all, recurrent dislocation and there are few statistics to help us, but all of us who have made investigation of this subject, know that it will easily reach one-eighth of all the cases.

Classification of luxations of the shoulder seems to be pretty well established and does not show any great variety in any of our so-called accepted text-books of surgery. There are five described varieties:

1. Subcoracoid—the most frequent.
2. Subclavicular—*subjudice*, we believe.
3. Subacromial.
4. Subspinous—very rare.
5. Subglenoid.

The subclavicular if it occurs, which is questionable, is a further forward dislocation than the subcoracoid, and is only possible with great injury. The subspinous is only a little further backward dislocation than the subacromial, but again with greater injury to soft tissue. Subglenoid is only an interrupted anterior dislocation, a half-way dislocation, as it were.

I do not deny that an intense local force would dislocate the shoulder in any direction. If it were sufficient, it could, by fracturing the acromion, produce even a superior dislocation, but such injuries are crushing injuries and the forces producing them are usually too extensive to produce a simple dislocation and this type means nearly always a tremendous crushing injury in which dislocation is secondary to a far greater injury. There is only one type of dislocation at the shoulder-joint, an inferior dislocation primarily and depending on the rotation, external or internal, an anterior or a posterior final position of the head of the humerus.

Consider the anatomy of the shoulder-joint, and the normal abduction of the arm which it is necessary to understand in order to comprehend the mechanics of shoulder dislocation, because the shoulder dislocates always in abduction. It is necessary to a proper understanding of the mechanics of the shoulder-joint, to disregard the capsule of the joint, because the capsule is a loose bag whose function is to manufacture and to retain the lubricating substance of the joint and it is extremely unlikely that it has any other function. It certainly does not hold the head of the humerus in place in any way on the glenoid cavity of the scapula, and only in one position, extreme abduction, is there even tensing of the capsular structure and this only of the inferior portion.

If one has any doubt of this fact, he has only to remove the muscular attachment from the shoulder-joint. Remove the deltoid, the biceps, the coraco brachialis, and the triceps muscles—all of which in the condition of normal tonus tend to hold up the arm. Still the humeral head is held into its socket on the glenoid, but divide the supraspinatus muscle and the short

posterior rotators and the subscapularis, and immediately there is complete relaxation and the head of the humerus can be pulled out of its socket. It will drop out of its socket of its own weight. If we consider the humerus as a lever, it is easy to see that the deltoid cannot start the arc of abduction. This is the function ordinarily of the supraspinatus up to the point where the mean line of the deltoid pull will fall superiorly to the fulcrum of the lever, which is upon the glenoid as shown in plate one. This lever is an angled lever and the supraspinatus from its insertion into the short arm of the lever can start the arc of abduction and keep it going until the line of pull of the deltoid has risen above the fulcrum of the lever so as to be able to exert its pull. A certain amount of pseudo abduction of the arm can be accomplished by the simultaneous action of the trapezius, and the serratus magnus where the supraspinatus and deltoid are paralyzed, but it is only a pseudo abduction which is limited in extent and is only due to the lifting of the base for the fulcrum of the lever, that is, the glenoid cavity of the scapula. The recent contention that active abduction, in its last arc, is due to action of the trapezius is fallacious, and the fact which has been cited as evidence in favor of this contention, that in some cases of paralysis of the spinal accessory nerve, the arm cannot be lifted in abduction beyond the horizontal is due to the loss of action of the trapezius as a stabilizer of the base on which rests the fulcrum, allowing this fulcrum, the glenoid cavity of the scapula, to sink downward to a lower level so that in abduction with the hand in pronation, the greater tuberosity of the humerus strikes against the acromion process of the scapula before the level of the horizontal is reached, whereas in the normal this point is at or slightly above the horizontal, and because the loss of trapezius action makes it impossible for this muscle to turn upward the acromion from 90 to 130 degrees in abduction in order to get it out of the way of the greater tuberosity. This is the middle of abduction, however, and not the last arc.

The scapula has no bony connection with the trunk except through the clavicle and there is a limited motion possible at both the acromio-clavicular and sterno-clavicular articulation and the greatest amount of motion is at the sterno-clavicular joint.

The scapula is a plate of bone with muscular attachments which are connected to it from every conceivable angle and within limits its position depends on the action or over action of certain muscles or groups of muscles. The levator anguli scapulæ is attached to its posterior superior border, the rhomboids to its posterior inner edge, the pectoralis minor to its coracoid process, the trapezius to the entire length of the spinous process, to the acromion and the outer part of the clavicle and the serratus magnus to its anterior inner border.

The other muscles which bind it to the humerus may be for the moment disregarded.

It is evident that here is a bone which possesses very little stability. It is easily movable in any direction, the only check being the limits of elasticity

of these muscular attachments and a very small articular surface which, in itself, possesses considerable motion. Upon this unstable foundation we must remember that we depend for a base for our lever when we consider the humerus as a lever which we must do in a study of the mechanics of the normal abduction of the arm.

Now, let us group these muscles as regards their action so far as the position of the glenoid cavity of the scapular is concerned. Because the glenoid is the base on which our lever rests. A lever is only a lever because it has a base and the base is as important as the lever. If the base is unstable the lever will fail and this base of ours depends upon muscular contraction for its stability. Over-action or loss of action by any particular group of muscles or by any individual muscle will, it is plain to see, affect our base and therefore affect our lever as much as if it were an actual interference with the lever itself. The position of the base will depend upon synchronization of all the muscular attachments.

The levator anguli scapulæ tends to pull up the superior posterior angle of the scapula and therefore to tip the glenoid downward. The pectoralis minor will tend also to tip the glenoid downard and the rhomboids not only pull the scapular inward towards the spine, but also tend to tilt downard the glenoid. Against these forces is the trapezius which raises the scapula, especially the acromion as in shrugging the shoulders, and from its oblique insertion, the superior portion not only raises the acromion but tilts it upward and therefore tilts upward the glenoid as well. This muscle acting by its inferior fibres has an exactly opposite effect, but it is an established fact that this muscle acts through separate bundles which are separately innervated and we are especially concerned as regards abduction with the action of its superior portion. The serratus magnus tends to swing the outer portion of the scapula backward as in the military position of the shoulders and also has the ability to swing outward the scapula thus tilting upward the glenoid cavity.

The trapezius raises the shoulder, that is, it raises the acromion process of the scapula and the clavicle, the whole moving upward on the sterno-clavicular joint as a hinge and together with the serratus magnus it rotates the scapula outward from the side. These two muscles acting together raise the base of the lever and steady it at a higher level, thus permitting the continuance of abduction between 90 and 130 degrees. It is evident by the obvious outward swing of the inferior angle of the scapula. But above this point the restriction is absolute in the usual type of normal abduction. The level of this locking is individual and varies within considerable limits, and it is a fact that there are certain individuals whose external tuberosities are small or the space between the tuberosity and the tip of the acromion is greater than in the ordinary type, thus allowing them to lift their arm in the position of abduction with the hand in pronation to a much higher level, but this is not the ordinary type.

Figure 10 gives the view of a man, who, normally, can abduct his arm with his hand in pronation to the side of his head, that is, 180 degrees. Why?

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The greater tuberosity of the humerus in his case comes in contact with the tip of the acromion when his arm is at 90 degrees of abduction and from this point the inferior edge of the scapula can be seen to swing outward as the acromion is pushed upward by the greater tuberosity or lifted upward by the action of the trapezius and serratus. At 130 degrees, however, the scapula ceases to move outward to any great extent, the greater tuberosity is felt to
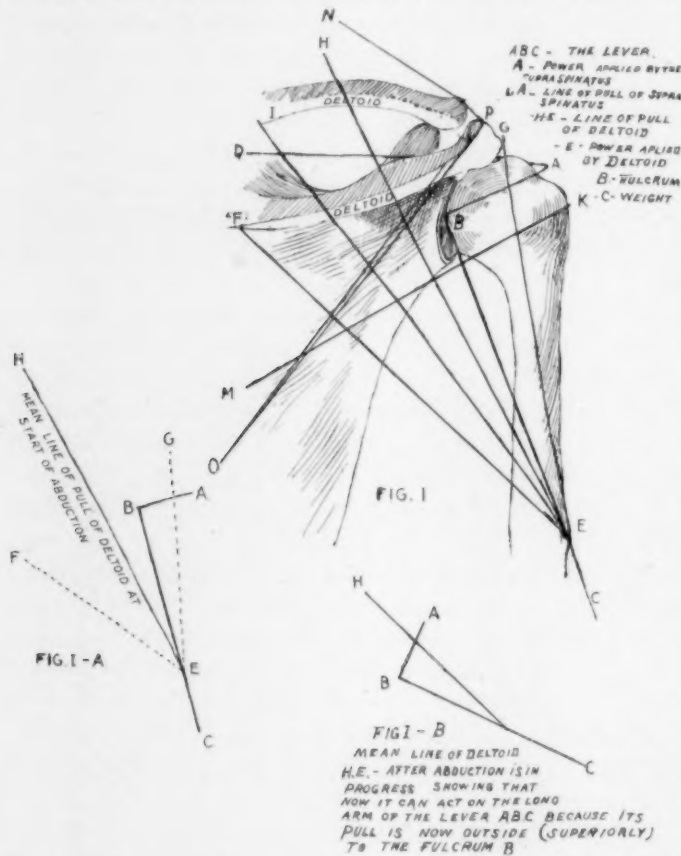

ABC - THE LEVER.
A - POWER APPLIED BY THE SUPRASPINATUS
L.A. - LINE OF PULL OF SUPRA SPINATUS
H.E. - LINE OF PULL OF DELTOID
E - POWER APLIED BY DELTOID
B - FULCRUM
K C- WEIGHT

FIG. I.

FIG. I-A

MEAN LINE OF PULL OF DELTOID AT START OF ABDUCTION

FIG I - B
MEAN LINE OF DELTOID
H.E. - AFTER ABDUCTION IS IN PROGRESS SHOWING THAT NOW IT CAN ACT ON THE LONG ARM OF THE LEVER ABC BECAUSE ITS PULL IS NOW OUTSIDE (SUPERIORLY) TO THE FULCRUM B

FIG. I.—Showing the lines of pull of the fibres of the deltoid providing these fibres acted together, H-E being approximately the line of such pull showing that in this case it could not act on the lever A-B-C to abduct it. Assuming that the acromion portion of the deltoid acted as a separate muscle or as a separate contraction, then it could (consider the line G-E and its effect acting at E on the long arm of the lever A-B-C) aid in starting the humerus upward in abduction, but should the fibres act simultaneously, the line of pull would be inside the fulcrum B, and provided it was in contraction, it would act in opposition to the line of pull of the supraspinatus, D-A. In order to act on the long arm of the lever, the line H-E must fall outside the point B (fulcrum), and this is possible only after the long arm of the lever (the humerus) has been partially abducted, which is done up to this point by the supraspinatus D-A acting at A on the short arm of the lever A-B-C, A the power, B the fulcrum, and C the weight of the arm to be abducted. K-M shows the line of pull of the short rotaters causing external rotation, especially pronounced once there is a fracture of the surgical neck putting out of commission the opposition of the pectoralis

major and latissimus dorsi and teres major muscles. The trapezius N-P-O is inserted into the area of the clavicle and spinous process which is shaded above the deltoid origin, and if the superior fibres represented by N-P acted separately, it is clearly seen that it might raise the glenoid to a higher position. This action would also be accentuated by the action of the serratus magnus, which would also tilt upward the whole scapula, and therefore, raise the glenoid. But neither would have any influence in direct abduction except by raising this base on which the fulcrum rests. Likewise, it is obvious that if the upper fibres of the trapezius were paralyzed, the antagonists would tend to tilt downward the glenoid. The pectoralis minor especially would tend to do this, and it would be aided by the levator anguli scapulæ and the rhomboids. The lower fibres of the trapezius, however, are not elevators but depressors of the scapula P-O. Even with a paralyzed trapezius, it must not be forgotten that much of this tendency to sag would be counteracted especially under effort by the serratus magnus muscle. With a paralyzed deltoid and a paralyzed supraspinatus, if the triceps, the biceps and the short rotaters or enough of them were intact so as to lock the scapula and humerus together, the action of the trapezius upper fibres and the serratus magnus would enable the patient to move outward the arm, but it would be the first arc of abduction, and not the last, and it would not be a free, easy abduction at the scapulo humeral joint. It would only be a swinging outward of the locked entire shoulder girdle and it would be limited. It would be analogous to the abduction, which is possible with an ankylosed shoulder. Many muscles have individual action of their various parts, and this applies to the trapezius and to the pectoralis major.

slip under the acromion even with his hand in this position of pronation and he continues to abduct to 180 degrees. The trapezius has simply raised the acromion up in order to give more room for the rotating head and when this

is accomplished and the head is able to rotate under the acromion its further action is synchronous with that of other muscles of the scapula in the holding of the glenoid firmly in its raised position.

Consider the active part of the lever, so far as abduction is concerned. Figures 1 and 2 will explain much of the mechanics of active abduction. Abduction is somewhat of a misnomer. Do we mean abduction in pronation or abduction in supination? Abduction in pronation which is what we usually mean by the term "abduction" is in the ordinary individual due first to the action of the supraspinatus which starts the motion. Then the deltoid goes into action and continues the abduction of the arm. Even with the supraspinatus paralyzed, the arc of abduction may sometimes be started, but this is done only by locking the humerus and scapula together by muscular action and using the trapezius and serratus magnus to lift up the base and to swing outward the whole locked structure.
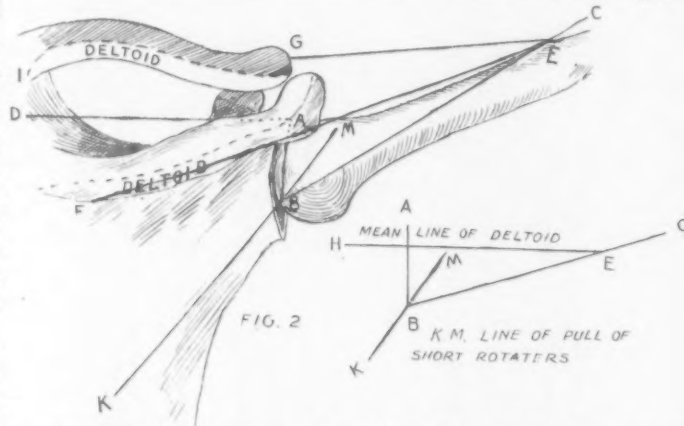

FIG. 2.—This shows the lines of pull of the deltoid when the arm is partially abducted. G-E, F-E and I-E and the line of pull of the supraspinatus D-A acting on the short arm of the lever A-B-C, while the deltoid acts on the long arm of the same lever, its power being applied to E, a point between the weight C and the fulcrum B. Note also that both lines of pull, deltoid and supraspinatus, are above the fulcrum B and unless there is another force applied the fulcrum of the lever would be unstabled and render worthless any amount of power applied. That force F-M, a line of pull of the infraspinatus, and teres minor behind and of the subscapularis in front is supplied by these three short rotators without which the head of the humerus would slip upward, answering the pull of the supraspinatus and deltoid. Note that the line of pull of the short rotators passes through the fulcrum B, therefore, it acts merely as a tractor and exerts no force either on the long or short arm of the lever, consequently offering no impediment to the abduction, while at the same time rendering such action possible by keeping the fulcrum firmly in place.

It is not the normal easy abduction of the arm from the glenoid and it is extremely limited. Figure 1 shows the supraspinatus action and the deltoid action both pulling the arm upward in abduction, the tendency would be to pull the head of the humerus, so that, if this force continued without restraint the head of the humerus would be pulled up against the under surface of the acromion and there would begin to be restriction to the normal arc of abduction when the humerus had swung upward to 40 or more degrees. The arm is therefore a lever with an unstable fulcrum and the bone slips and abduction is impossible. A lever is only efficient if it has a fulcrum that is stable as well as a base. A slip of $1/100$th or $1/1000$th of an inch would be as fatal to its efficiency as a greater one. There must be another force or pull here at a different angle than either of the forces which we have considered; a force which will oppose this tendency to upward displacement of the abducting head of the humerus and pull it down-

ward, at the same time not impeding the rotation of the head and this force is supplied by the short posterior rotators behind and the subscapularis in front, forming a veritable sling about the head of the humerus pulling it downward away from the acromion and fixing it firmly into its place against the glenoid cavity of the scapula. Figure 2 shows the line of pull of the short rotators of the shoulder such as to hold the head of the humerus in its place on the glenoid. Inasmuch as the line of pull falls through the fulcrum, it does not obstruct the movement of the abduction in any way, and by pulling the head of the humerus firmly into place and keeping it there, it prevents riding up of the head under the acromion, while at the same time helping to lift the acromion and makes abduction a possibility. Remove from this lever these short rotators, either by operation or paralysis, and with the deltoid intact, and the supraspinatus acting, the man will not abduct his arm beyond 45 or 50 degrees, and only then by a tremendous effort. So that this sling of elasticity, about
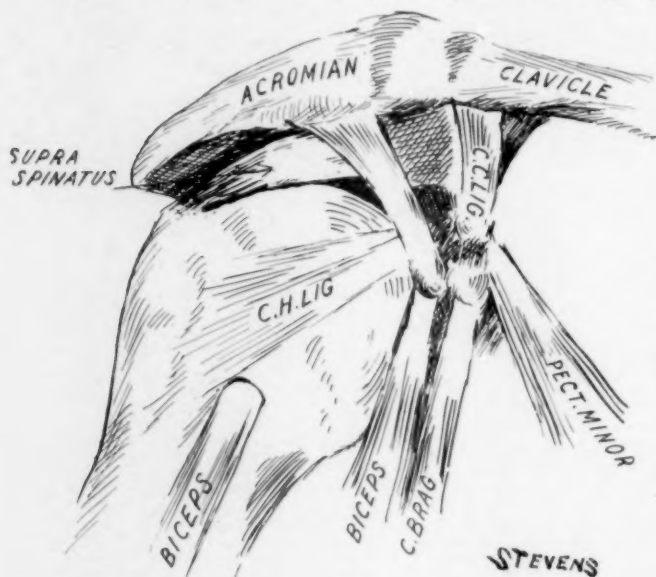

FIG. 3.—This view shows how impossible a sub-clavicular position of the dislocating head would be without other injuries greater than the dislocation. In order to reach that position, the head would either have to come through between the two heads of the biceps and then ride over the coracoid or under the short head of the biceps and coracoid. The first way, the subscapularis, the infraspinatus and the teres would all have to be ruptured and the coraco acromion lig. and supraspinatus probably. If the head came out as it does under the short head of the biceps and coraco brac. either these two muscles would have to be ruptured or the coracoid process fractured in addition to the pathology stated above in order that the head should become sub-clavicular.

the neck of the humerus is of as much importance to the normal abduction of the arm as a functionating deltoid or supraspinatus muscle.

It is necessary to remember that this external rotation movement of the humerus which seems so easy to execute, is accomplished by the infraspinatus and teres minor muscles overacting as compared with the subscapularis; nevertheless, at the same time, these three muscles must keep up their tension in order to keep the fulcrum of the lever, the humeral head, firmly in the glenoid. If they relax for an instant, this steady elastic pressure, the lever fails, and down will go the arm to the side. A deltoid as strong as a lion's paw would only make matters worse, because a lever is only as stable as its fulcrum. (See article on action of short rotators in the *American Journal of Medical Sciences* of 1909.) This is exactly what does take place

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in these cases of a paralysis or partial paralysis from injury of the short rotators. The head of the bone rides and while the patient can abduct up to 45 or 50 degrees, then comes restriction. The short rotators paralyzed, or if not paralyzed, sometimes refusing to function because of tenderness in their injured tendons, or from tenderness in the floor of the bursal sack, which is directly above them, refuses to work. The presence of calcareous deposits in these tendons, as well as in the tendon of the supraspinatus, is usually the evidence of old injury and will be found oftener in those patients who have at some time suffered from an old dislocation at the shoulder-joint, or an old injury which has caused straining of these tendons.

In the ordinary type in abduction, in pronation, the greater tuberosity strikes against the lower side of the acromion when the arm has swung up to about 90 degrees and further motion is impossible, except as the acromion process is lifted, the entire scapula rotating outward. The trapezius which is the shrug-

FIG. 4.—Shows by arrow 1, the increase of distance the supraspinatus would traverse if dislocated anteriorly under the coracoid, and how impossible it would be without rupture of this tendon and many others to further dislocate the head of the humerus under the clavicle. Arrows 2 and 3 show the greater distance which would have to be traversed by the infraspinatus and teres minor, in order that the anterior dislocation should be possible. The tendons would be under great strain across the empty glenoid. Impossible for the head to go further anterior under the clavicle without rupture, and also a broken coracoid or ruptured biceps and coraco brachialis. Even then the subscapularis would prevent it. Arrow 4 shows shorter distance of supraspinatus to its new position at C in posterior type of dislocation.

ging muscle of the shoulder, rotates the scapula and lifts it up in order to increase the ability of the head of the humerus to rotate under the acromion. The serratus and the short rotators aid in this same movement and the clavicle rises also. They fix the scapula firmly in this raised position and this being the base of the lever, permits the degrees of abduction between 90 and 130 degrees, while they do not actually abduct. Here again comes restriction. There is restriction because the greater tuberosity still impinges upon the tip of the acromion process and the acromion has been tilted to its limit. Further motion is impossible. Now, by externally rotating the humeral head so that the hand is in supination, the groove in the humerus between the greater and lesser tuberosities comes into line with the tip of the acromion
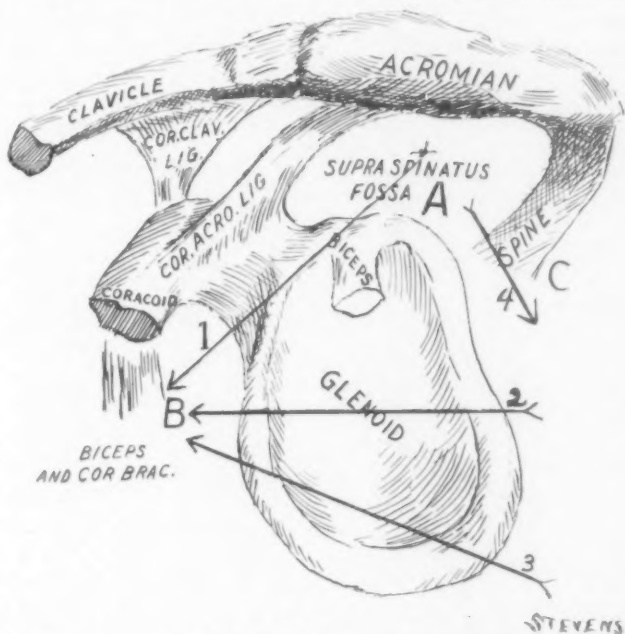
and there is just clearance enough to permit further abduction as the greater tuberosity rotates under the acromion, and in both types when the tuberosity rotates under the acromion, the scapula ceases to turn outward to any great extent. The clavicle ceases to rise at this point, which it would not do if this further action were due to the trapezius. The further swing of the inferior tip of the scapula is less pronounced and what little there is, is decidedly forward, instead of directly out. In some cases the turning is nil, once this point has been reached.

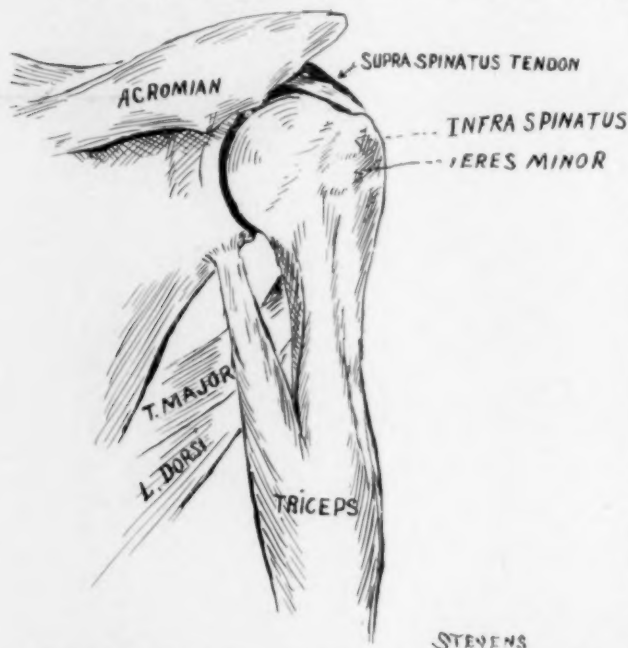The muscles which accomplish the last arc of abduction especially with the hand in the position of supination, which is necessary for the completion of abduction in the vast majority of cases, are the deltoid, the biceps, the pectoralis major, and the triceps. How can it be otherwise? The biceps runs across two joint surfaces and therefore it f l e x e s both. The t r i c e p s runs across one movable surface, and by its action it keeps the forearm in a fixed p o s i t i o n, therefore making a fixed point upon which the biceps can exert its action, without flexing t h e forearm, in this way

Fig. 5.—This figure shows the lessened strain, both on the supra-spinatus and infraspinatus, and teres tendons, which would result once a posterior dislocation had occurred. The strain in this form of dislocation obviously would fall upon the subscapularis tendon in front, except for the immediate strain thrown upon the supraspinatus at the time of dislocation. This figure also shows the well protected surface of the joint from behind if we reconstruct visually the infraspinatus and teres minor.

transferring all its action to the shoulder. This action is, however, limited.

The pectoralis major runs across the upper joint and the clavicular portion innervated from the fifth cervical root, becomes an abductor of the humerus after the arm has swung beyond the horizontal. After the arm has swung upward to 130 degrees if one will note its strength of contraction, he will conclude that it is a tremendous abductor, and it constitutes, together with the deltoid which is still able to function, after the tuberosity has rotated under the tip of the acromion or after the tip of the acromion has been lifted and rotated out of the way by the trapezius and serratus, the main power in abduction in its final arc.

The trapezius and the serratus magnus from now on are only fixers,

stabilizers of the scapula, but they have a very limited action except between 90 and 130 degrees so far as abduction of the arm is concerned. Almost as much can be said for all the other muscles attached to the scapula but nevertheless they are not to be termed abductors.

A dislocation of the shoulder anteriorly, that is, a primary dislocation of the shoulder, without first being an inferior dislocation, is an impossibility except perhaps as we have said, rarely as the result of an extreme local force in which the dislocation would be secondary to a tremendous crushing and tearing lesion. The same objection applies to a posterior dislocation. There is no such thing except as applies also to the anterior in the face of an overwhelming local crushing force. The rent in the capsule usually runs up as high as the coraco-humeral ligament, which runs across anteriorly from the coracoid process to the humeral head, and is in reality a thickening of the capsule. The capsule is always torn away from the glenoid rim and never from the humeral head. Why? Because the head of the bone in the position
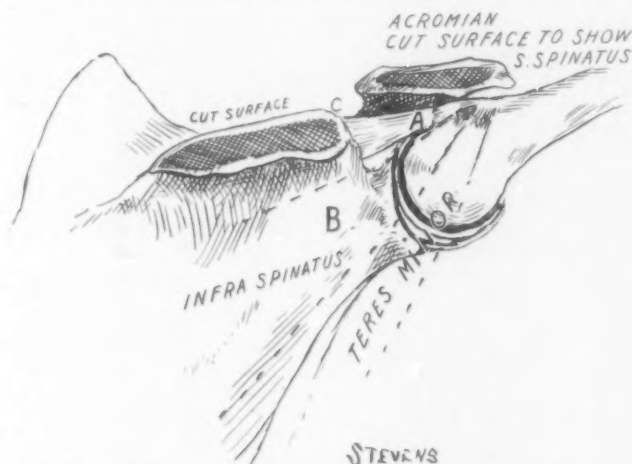

FIG. 6.—The acromion has been cut so as to show the insertion of the supraspinatus from behind. Note how well protected the posterior surface of the joint would be by the tendons of the infraspinatus and teres minor. This drawing also shows how these three muscles keep the head of the humerus against the glenoid, at the same time allowing abduction. In a posterior dislocation, note that the distance from C to A, normal position, would not be increased if A were transposed to B, the position of posterior dislocation, while the infraspinatus and teres minor would be relaxed.

of abduction is tensing the inferior portion of the capsule, and as external rotation comes, the head of the humerus brings local pressure to bear against a comparatively weak structure. This is the only portion of the capsule which is tensed under any condition and the direct pressure of the dislocating head is exerting local pressure against it. Were it a very strong membrane, it might tear anywhere but not so with a comparatively slight structure.

The normal abduction of the arm with the hand in pronation and with the arm in internal rotation, which is the position which one assumes when one falls, proceeds up to a certain point with ease, until well above a right angle where it is arrested. The greater tuberosity of the humerus goes bang up against the outer projection of the acromion process of the scapula. The scapula is forced upward by this force, but this upward motion is limited. If the force continues, the greater tuberosity is broken, the neck of the humerus is broken or, which rarely happens, the tip of the acromion breaks.

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If a man fell with his arm in this position, the hand in supination, his humerus would go smash up against his head and he would not break his shoulder and he would not dislocate his arm; but he does not fall like that. One falls with hand in pronation and arm in internal rotation, in order to save himself, and so the greater tuberosity impinges on the acromion process. The reason that a greater number of breaks of this type do not occur is this additional lifting of the scapula on the clavicular sternal and acromio-clavicular joints to the limit of elasticity permitted by the muscular attachments of the rhomboids, the pectoralis minor, the levator anguli scapulæ and the rhomboid ligament the action being of the same nature as the recoil mechanism of a gun.
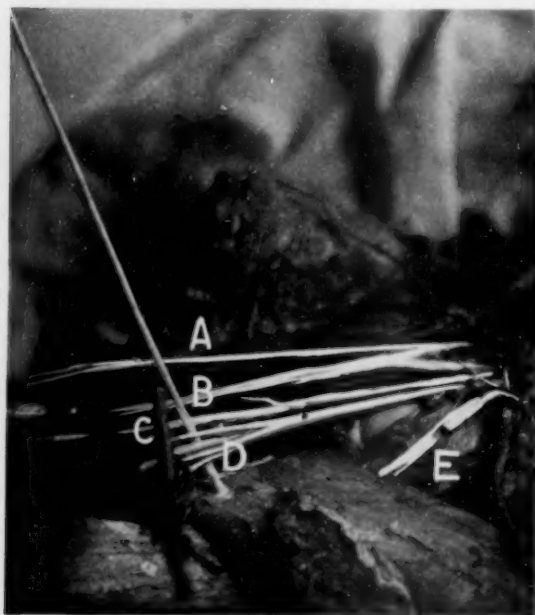

FIG. 7.—Shows dislocating head of humerus just coming through the capsule in anterior dislocation. Note the circumflex nerve directly over the head in this position of abduction of the arm. Is it any wonder that paralysis of deltoid follows so frequently? Note that this nerve and to a lesser extent the musculo-spiral, are more fixed in position because both pass under muscular structure and through layers of restricting fascia, which binds them down so that a stretching is more serious than in the others. In the order of their fixity, these nerves are the circumflex, the musculo-spiral and the musculo-cutaneous, and, therefore, these three are more likely to be injured by strain. In the position of abduction the musculo-cutaneous is superior and, therefore, above the major strain imposed by a dislocating head, in most cases. The head of the humerus has come out in some cases even between the two heads of the median. Visualize, in such a case, what a leverage reduction might do.

If all these structures hold and there is no break or even if the break in the greater tuberosity which frequently happens, is not enough to release the pressure, the force continues. The pressure of the tip of the acromion is trying to push the humerus into external rotation and release it. If this were a slow process, it would accomplish its task. It also acts now to force the head of the humerus not only downward, but to lift it out of the glenoid cavity, because for this stress a new lever with its fulcrum on the tip of the acromion, is established and where the head has partly rotated under the acromion, the leverage is transferred to the neck of the humerus and often results in a fracture of the neck of our Type II class: See " Fracture of the Upper End of the Humerus," ANNALS OF SURGERY, 1919.

The supraspinatus muscle is not tense but is relaxed and the head of the humerus slides downward and the inferior portion of the capsule is tensed. Even now the head of the humerus would not dislocate even if the capsule tore in the majority of cases. But just at this instant when the head of the humerus is forced downward to rest on the inferior rim of the glenoid,

literally lifted on to the glenoid rim, comes the movement of external rotation, not half-way, but extreme external rotation, and the head is twisted out of the glenoid and through the inferior torn portion of the capsule. If you have ever externally rotated an arm from which the pectoralis major muscle has been removed, you will be impressed at the way in which the head of the humerus will rotate to the front of the glenoid and become prominent. Once the head of the bone has slipped out of the inferior rim of the glenoid, the future position of the head depends entirely upon the position of the arm as regards rotation. If in external rotation, which is the position which all the forces tend to produce nine times out of ten, the force of the acromion pushing on the greater tuberosity, or on the neck if the tuberosity has succeeded in slipping under, the force against the elbow and forearm externally as the man falls on his side, as he does naturally, all tend to further externally rotate the humerus.

Result, a humerus whose position in abduction and leverage against the acromion, the arm being in internal rotation has withstood the hammer blow against the process without f r a c t u r e of the greater tuberosity and without fracture of the neck of the
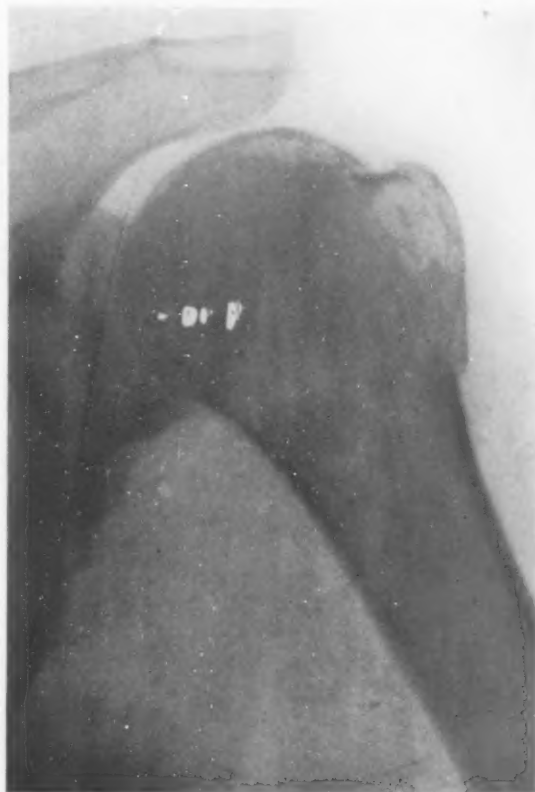
FIG. 8.—This represents a type of fracture which is fairly common with dislocation of the shoulder. It is an impact separation of the greater tuberosity, and is not due to the same mechanics as that represented by Fig. 9, which is a periosteal tear from tension on the tendon. These two types are the most common complication in injury from dislocation.

humerus. It has been forced downward on the glenoid and by force of leverage against the head by the acromion the gliding surface of the bone has been lifted as well as forced downward on to the glenoid rim. External rotation, normal external rotation which would have permitted the normal depression in the humeral head between the greater and lesser tuberosity to come into line with the tip of the acromion process and so have permitted hyper-abduction and freedom of motion, thus releasing the pressure, has failed to materialize in time and then too late has come with extreme force. It is the last straw and out goes the head of the bone and the resulting discolation is a subcoracoid dislocation of the humerus. If exactly

at the moment when the head of the humerus is on the inferior rim of the glenoid, there is the unusual force of extreme internal instead of external rotation added, the resulting twist inward of the head of the humerus will have a tendency to force the articular surface backward and there will result either a subglenoid, in which the force of internal rotation has been small and only enough to counteract the tendency for the head of the bone to slip forward under the coracoid, or a still rarer type, a subacromial dislocation.

A dislocation of the shoulder anteriorly, especially, is an impossibility without putting a s t r a i n upon the tendons of the supraspinatus, the infras p i n a t u s, and the teres minor. If the dislocation is the subcoracoid one, which is the most common form, the distance from the origin of the supraspinatus to the new position of the greater tuberosity of the humerus under the coracoid is clearly greater in distance than in the normal position, and the tendon of the supraspinatus is also angled over the rim of the empty glenoid. See Figs. 3 and 4. Codman reported a number of cases of rupture of the supraspinatus tendon from being caught between the greater tuberosity and the acromion and while at the time we accepted that explanation, we have

Fig. 9.—This shows a type of lesion as common to dislocation as the type showing a definite separation of the greater tuberosity. The mechanics are different, however. This represents a periosteal tear of the insertion of the supraspinatus, and is caused by the strain on this tendon, usually at the time of dislocation. Undoubtedly, in a leverage reduction, it might also occur, but it usually takes place at the time of dislocation and is more common in the anterior types.

become more and more convinced that the supraspinatus is rarely or never caught between these bony prominences, but that it is the force producing a dislocation that causes rupture of this tendon. That is a rupture of the tendon *per se*, or a periosteal tear, and not a separation of its insertion into the greater tuberosity by a fracture which occurs frequently from impact on the acromion process as I have shown in a recent article (ANNALS OF SURGERY of 1919) (Fractures of the upper end of the humerus). We may, I think, assume that in every case of dislocation of the humerus and especially in anterior dis-

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location, there is injury to the tendon of the supraspinatus, and that often it is ruptured. If the discolation is further forward, a so-called subclavicular dislocation, if such exists, it is always ruptured. Otherwise, it would be impossible to put the head of the humerus in this position.

The infraspinatus and teres minor muscles are posterior and run outward from the posterior surface of the scapula to be inserted into the greater tuberosity of the humerus to complete with the anterior muscle, the subscapularis, the sling about the head of the bone which under tension makes it possible for the deltoid to abduct the arm. We have shown that if these are paralyzed or if they are injured or do not work smoothly the deltoid can only abduct the arm with difficulty and often not at all. Forty-five to fifty degrees of motion is possible and then restriction. Not from pain, not from any inability of the deltoid to do its work, but simply and solely because these short rotators refuse to work. The sling about the head of the humerus is not efficient and the head is not held firmly against the cavity. The same phenomenon will take place when a subscapularis tendon refuses to work, thus destroying the sling anteriorly, but injury to the subscapularis, except as a part of a brachial plexus paralysis is not so common as an injury to the posterior short rotators. In one case of ours,

FIG. 10.—Shows abduction in pronation. This type can abduct in this position to the side of the head. The outer end of the clavicle ceases to be raised, however, when 130 to 135 degrees has been reached. If the final arc beyond 135 degrees were due to trapezius action, this would not be so.

following an injury, not a dislocation, there was a paralysis of the subscapularis muscle, as a part of a paralysis which involved the latissimus dorsi, the pectoralis major, and minor tendons. The trapezius and the serratus were intact. The arm was externally rotated, therefore the infraspinatus and the teres minor were intact. The arc of abduction could be started, therefore the supraspinatus was intact. The deltoid took up its work and the arm could be abducted by strenuous effort, fifty to sixty degrees, but the weight of a finger placed upon it would send it down and beyond this it would not go.

Here we have identically the same result as before, the sling about the head of the humerus which is necessary to abduction, is out of commission. But this is rather unusual. In these cases of dislocation anteriorly, it is the posterior rotators which are injured exactly as the supraspinatus is injured, and oftentimes they are ruptured. The distance from their origin to their

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insertion on the greater tuberosity of the humerus in the position of sub-
coracoid dislocation, is much greater than normal and these tendons are
pulled straight over the posterior rim and inferior edge of the glenoid. They
are tense and they are always injured, sometimes more and sometimes less
and reacting to injury even if not entirely ruptured, they are inflamed and
never again are they exactly the same smooth resilient tendons which they
were before.

Any substance which is elastic or expansile and that has suffered a strain
which is greater than its tensile strength is never fully recovered from. This
applies to rubber or to steel or to iron or to muscle. It is one of the under-
lying principles of mechanics. In these anterior dislocations, the subscapu-
laris is not tensed. If anything it is relaxed. Leave the head of the bone
out for a short time and you will have a tense subscapularis from contraction;
so tense in old cases as to require division before reduction can be accom-
plished, but not in fresh cases. In a subcoracoid dislocation, the short head of
the biceps and the tendon of the coraco-brachialis are pushed forward over
the head and tensed also. The long head of the biceps is usually lax across the
joint and there is plenty of play so that usually it is not ruptured. In these
mild cases the head of the humerus is hardly off the glenoid anteriorly.

Anything which relaxes the biceps and coraco-brachialis and gives the
bone a push upward and posteriorly is enough to reduce it. What we actually
do by Kocher's method of reduction is to relax the biceps and coraco-
brachialis and by external rotation to use the posterior side of the greater
tuberosity against the anterior rim of the glenoid to lift the head and then
by carrying the arm across the front of the chest keeping the prying leverage
of external rotation, we also lever it against the coracoid and the head of
the bone slips up on the glenoid rim. It is a double leverage and a lift and
not as has been said by using the posterior portion of the capsule wound
about the head and neck to draw it into place. How by externally rotating
the head of the bone, the small amount which one does, can you wind the
posterior capsule about the neck of the humerus? What you do by external
rotation is to produce exactly the position of the capsule as when the accident
happened, and if the bone came out of the capsule in that position, it can
equally well go back if you reproduce the same condition backwards. If
anything you will unroll the posterior portion of the capsule instead of tensing
it, and this is exactly what you wish to do, and a little push upward and
backward at the same moment that you swing the arm across the chest will
help you tremendously after the capsule is unrolled and the rent made bigger.
The worst thing that can be said about it is that it is reduction by leverage,
the force being applied on the long arm of a lever of the first class, power,
fulcrum, weight and a tremendous leverage is obtained which improperly
used can also do a tremendous amount of damage. If you properly interpret
the condition, the greater tuberosity being against the anterior rim of the
glenoid, where it can be used to lift the head by external rotation of the arm,

you will succeed. If anything interferes and the head does not rise to the glenoid, you may tear your muscles more and you may even fracture the humerus or the coracoid thus creating greater trouble than you are trying to correct. If the head has pushed further along under the coracoid you will usually not reduce it by this method. Because the head of the humerus is too far away from the glenoid, and you cannot use the greater tuberosity against the glenoid rim as a fulcrum for your lever and it is wedged. Besides, in these cases, the muscular attachments, the supraspinatus, the infraspinatus and teres minor, are many times ruptured and they do not help as a fixed point against which resistance can be applied. The posterior capsule may be torn less in these anterior cases than in the posterior, but the reason that the head of the bone goes round and round as described by various writers is that it is too far away from the rim of the glenoid and there is rupture of these tendons, especially the supraspinatus and the infraspinatus and teres. The answer is abduction after flexion of the forearm to relax the biceps and coraco-brachialis and allow the head to slip back under these muscles which may hold it. First flexion, second abduction, because the arm went out in abduction; third, traction to pull it outward; fourth, external rotation to increase the hole in the capsule; this was the way it happened and if it went out that way, it can go back that way. Lastly, external rotation and traction having pulled it back to the rim of the glenoid, traction being kept up all the time, with one hand over the neck of the scapula and the fingers under the neck of the humerus, lift the humerus as the arm is swept downward across the front of the chest, external rotation thus being changed into internal rotation and the bone will traverse the same pathway which it followed in producing the injury but exactly reversed.

By flexion, we relax the muscles over the head. By traction in abduction we lift the head from under the coracoid. The subscapularis is already relaxed and we get the posterior edge of the gliding surface up to and on to the rim of the glenoid. By external rotation we relax the infraspinatus and teres minor and increase the size of the rent in the capsule. By local pressure upward and backward with the hand, we help the head of the bone over the rim and by changing into internal rotation, we tense the infraspinatus and teres when not ruptured just at the moment when we need their action to pull the head backward. If they are ruptured nevertheless we lift the head into place, and internal rotation carries the head backward toward the posterior surface of the glenoid, just as external rotation has a tendency to bring it towards the anterior portion.

In the subclavicular form, if such a form really exists (I have never seen one) the injury must be much greater in extent. If the head of the humerus comes out of the glenoid and comes to rest under the short head of the biceps and coraco-brachialis, as it does in all the cases that I have seen, then in order to become subclavicular it can only do so by rupture of the short head of the biceps and the coraco-brachialis or fracture of the coracoid. The

pectoralis minor is also in the way and a tremendous tearing of all these structures or their rupture is necessary in order to place the head of the humerus in any subclavicular position. Assuming that the head was anterior to the short head of the biceps and had come through between the two bicipital heads, as it would have to do to be in that relation, it would nevertheless be impossible to reach a position under the clavicle without tremendous tearing of muscles and tendons. The supraspinatus in most of these cases would have to be torn, the infraspinatus and teres minor always, and the subscapularis also and an injury of this nature is rather difficult to imagine. I prefer to think that it is at least a very rare form, if it exists at all, which I doubt. At any rate, if such a position does occasionally happen the only efficient reduction would be by abduction and traction as the first part of the procedure. Try it on the skeleton and visualize the damage to the soft parts. It cannot reach the subclavicular position above the coracoid without the fracture of that process and the subscapularis would prevent its going far in that direction even if the coracoid were broken, and the posterior short rotators ruptured. It cannot reach that position from under the coracoid and the tendons of the coraco-brachialis and short head of the biceps except by fracturing the coracoid or rupturing these tendons. If any man has a plate representing such a dislocation I should like to see it.

Posterior Dislocation, Subspinous, Subacromial.—The capsule is apt to be torn more than in the anterior type. It has been said that the infraspinatus and teres minor are often torn but fortunately this is not as true for posterior as for anterior dislocation. Posterior dislocations are simply a variation of the inferior dislocation due to the sudden strain of internal rotation thrown upon the humerus at the moment when the head of the bone is sliding over the inferior rim of the glenoid fossa. The arm is in abduction exactly as it is in anterior dislocation. Up to the moment of actual dislocation the movement is as we have said; abduction, a slipping down of the head on the glenoid, aided by the prying of the greater tuberosity against the acromion, then comes internal rotation instead of external rotation, as in anterior dislocation and the head of the bone goes out and comes to rest posteriorly. The supraspinatus tendon is necessarily stretched as the head slips down and out of the glenoid exactly as it is in the anterior type, but after it has posteriorly dislocated, the distance to its new position is hardly greater than in the normal position. By referring to Fig. 6, the normal position of the insertion of the supraspinatus at A, would hardly be much increased if changed to the dislocated position at B, and the only injury which the tendon would sustain would be at the moment of its dislocation, or a damage to its insertion on the greater tuberosity of the humerus by the impact of abduction against the acromion. This very often happens, the greater tuberosity being split loose together with the insertion of the supraspinatus, the infraspinatus and the teres minor. The danger of damage to the tendons of the infraspinatus and teres minor is much less in posterior dislocations, as can be readily seen from

a glance at Figs. 5 and 6. The subscapularis may suffer, however, since it is put on the stretch more in the posterior form and if so, we have exactly the same condition of injury to the humeral sling as we had in the anterior form from damage to the posterior rotators; but there is a greater tendency for this muscle to slip under the glenoid, thus saving itself from a certain amount of strain, stressed often, but seldom ruptured. The further out the head of the humerus is under the spine the greater the likelihood of rupture of tendons.

The reduction of this type is by a reversal of the methods by which the dislocation happened. Flexion of the forearm is, however, not so important as in the anterior type because the biceps and coraco-brachialis are not tensed. The important movements are abduction, traction, internal rotation to widen the rent in the capsule, and lastly when the head of the bone has risen to the glenoid rim, local lifting and external rotation and bringing the arm down to the side.

Stimson's position of a hanging arm with ten pounds attached to the wrist, accomplishes this reduction in much the same way, both for anterior and posterior dislocation, but he does not flex the arm which is a distinct advantage. He does not advocate the rotation, and rotation is a distinct advantage which can easily be added to his method, and it then becomes a reduction, practically the same as we use: hang the weight on the flexed elbow and not on the wrist.

Now we have reduced our dislocation, whether anterior or posterior, and what do we do? We put the arm into internal rotation. We put on a sling and a swathe at least, but always in internal rotation. The patient has only suffered a dislocation of the arm. It has been reduced. He can see no reason for being in bed and he insists on going about. If the damage has been little he comes out fairly well, with from ten to twenty days of restriction of motion depending upon the surgeon who treats him, but full recovery is many times not attained and recurrent dislocation is common. Much of this subsequent trouble is due in our opinion to the position in which one treats these primary dislocations of the shoulder after reduction. Internal rotation twists the head of the bone inward and keeps on stretch the already over-stretched infraspinatus and teres, and keeps them apart if they are actually ruptured. The position of the arm at the side allows the full weight of the arm, and it is no inconsiderable weight, to fall, not alone upon the deltoid, but upon the supraspinatus muscle, already overstretched and perhaps rup-tured. If ruptured, the head of the bone falls away from the acromion as can be demonstrated by the X-ray if taken in the standing position, and the healing of the damaged muscle or tendon, like healing of the damaged muscles or tendons of the infraspinatus and teres minor is permitted to go on in this position of overstretch. If they are simply overstretched, a good deal of recovery is certain. The result is that in most cases, these muscles never fully recover their tone. Their tendons never fully recover that smooth action

which is theirs from the normal elasticity of uninjured muscle fibre. There are oftentimes deposits from an inflammatory reaction in the tendons under the bursa; there is scar tissue which prevents smooth action, there is an instability of the shoulder and a tendency to recurrence of the dislocation, simply because these muscles have healed in an overstretched position and the weight of the arm never allows them to recover their normal tonus again.

Scar tissue never has the resilience of normal tissue. All these cases of dislocation of the shoulder anteriorly should be treated by abduction and external rotation for a period of not less than ten days and often more, and then gentle passive and active motion, and if so treated we shall see the passing of this tremendous number who develop recurrent dislocation.

In the case of the posterior dislocations, external rotation is not of so great an importance as in the cases of anterior dislocation, because the posterior short rotators are much less apt to be injured, but the supraspinatus is injured in both. The position of abduction not only relaxes these muscles, but it permits of the drainage of the joint itself through the rent in the capsule, and this joint is always traumatized and full of fluid. By the raising of the arm in abduction, and rotation, the capsule itself is straightened out as it were, and by gentle passive motion through a few degrees of arc only in these first days, the joint empties itself of the products of this inflammation through the capsular rent into the surrounding tissue where its absorption is more likely than when confined within the capsule. Synovial membrane is never an absorbing membrane. The edges of the torn capsule in this position are brought together without infolding and repair is rapid. Ten days in this position, or in some cases of exceptionally severe injury longer, and after that a sling to lift the elbow up and prevent sagging by the weight of the arm upon these injured muscles. Recurrent dislocations at the shoulder-joint are due always to more or less tearing of the supraspinatus, the infraspinatus and teres minor and more rarely of the subscapularis and their subsequent repair by scar tissue in the position of stretch. Dropping of the head of the humerus is due always to extensive injury of the supraspinatus muscle and not to the deltoid injury. The deltoid, while a very strong muscle is of long muscle fibre, and muscle fibre of itself will stretch under weight. The long head of the biceps where it crosses the capsule is not tense save under contraction. It is remarkably loose and that is the reason that it is not more frequently ruptured either in dislocation or fracture of the neck of the humerus, although we have seen this rupture of the long head of the biceps several times in both varieties of injury. Were these muscles together with the triceps behind responsible for the position of the head of the humerus in the glenoid, then the head of this bone except when these muscles were tense would always slip down from its normal position under the acromion. It is the shorter, more fibrous and shorter bellied supraspinatus and the short rotators, aided by atmospheric pressure, which prevents this drop and a paralysis of the suprascapular nerve, without paralysis of the

deltoid, will show this dropping nearly always. Reefing the capsule of the shoulder-joint to prevent recurrent dislocation is illogical. Reefing the tendons of the supraspinatus and the tendons of the infraspinatus and teres minor is the logical procedure for recurrent dislocation at the shoulder-joint.

Rarely, the subscapularis will also have to be tensed, but not often. Gentle passive motion, through a few degrees of arc, while the arm is in the abducted position, during the first ten days, following a dislocation, and then bringing the arm to the side with restriction and freedom from weight with gentle passive and active motion to the shoulder-joint for ten days longer will do away with the greater number of these recurrent dislocations of the shoulder-joint and will give us results which will not present Schultz's terrible statistical figures.

ARTHRODESIS OF THE ELBOW *

By Astley P. C. Ashhurst, M.D.

of Philadelphia, Pa.

Arthrodesis, or the production of ankylosis in a joint, is frequently employed in the tarsus, occasionally in the shoulder, wrist, hip or knee, but is very seldom indicated in the elbow.

In most instances it is adopted at the locations first named to overcome disability resulting from flail joints due to infantile paralysis. The elbow-joint is seldom rendered so utterly useless by infantile paralysis that arthrodesis is required to improve the function of the limb; in almost all cases enough power will be regained in the flexor muscles to enable the patient to control the joint, even if considerable weakness persists. If the flexor muscles of the elbow remain powerless, the muscles arising from the external condyle may have their origin shifted by operation to a higher point on the humerus, and thus obtain enough leverage to render them efficient as flexors of the elbow. Indeed, in their normal position these muscles, especially the brachioradialis, may act efficiently as flexors of the elbow, as I had occasion to observe some years ago in a patient with accidental (operative) section of the musculocutaneous nerve, which paralyzed the biceps, coraco-brachialis and brachialis anticus (though the brachialis occasionally receives a filament from the radial nerve). In this patient flexion of the elbow was active, though weak, from the very time of operation, and no other disability was noted during the interval of a few months until regeneration of the sutured nerve occurred. But in a paralytic patient with power absent also in the forearm, and only very weak power in the fingers, the resource of muscle transfer is not available; and it becomes necessary to adopt some other method to keep the elbow flexed and bring the feeble hand into a position where it will be of some use. Of course a sling or a brace can be constantly worn, holding the elbow at a right angle; but as a rule a patient will not be satisfied to be condemned to the employment of such apparatus through life, and some operative means of relief will be sought. It was, I believe, for such cases as these that Sir Robert Jones advocated an operation known by his name, and which consists in excising a large ellipse of skin from the flexure of the elbow, and suturing its edges together after flexing the forearm acutely on the arm. It may be that in some cases this will act as a temporary expedient to relieve strain on the flexor muscles of the elbow, and that the latter will recover their power before the force of gravity overcomes the pull upward

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* Read before the Philadelphia Academy of Surgery, October 5, 1925.

of the skin plastic. But in such cases a sling or a brace will be as efficient a temporary prosthesis as the plastic operation; and I had never employed the operation of Jones until encountering the second patient whose history will be detailed, in whom the paralysis seemed permanent. It was a great disappointment to find that the elbow flexion secured by Jones's operation was not also permanent, but that it was overcome, gradually but surely in the course of a few months, by the mere force of gravity.

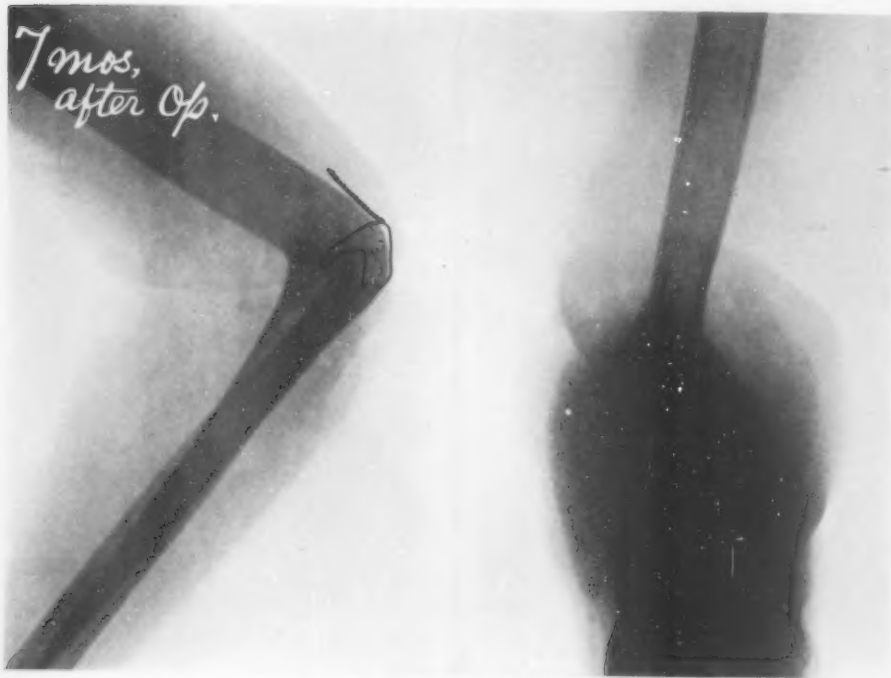There is another class of cases in which the flail elbow is due not so

FIG. 1.—Case I. Skiagraph made seven months after operation showing bony ankylosis.

much to paralysis as to excessive destruction of bone. Such cases are seen in military but not often in civil life. It was not until after I had made an arthrodesis at the elbow of the first patient whose history is narrated below, that I found (August, 1923) the following very unfavorable account given of the procedure which I had employed, and which proved perfectly successful in my hands. W. Mercer, in the *Lancet* of April 21, 1923 (vol. cciv, p. 796), writes as follows: " Previous to the operation I am about to describe, I have not seen a successful result from arthrodesis (of the elbow); the elbow is admittedly not an easy joint to deal with, but I am sure that most of the bad results are due to badly planned operations. The adjoining surfaces of radius and ulna have been bared in wedge-shaped fashion, and the humerus similarly

bared and wedged between the ends of the forearm bones. Even with wiring no stability resulted from this union; ankylosis must have been very rare and had never occurred in any case I saw. Having little faith in this operation, I never performed it." He then reports two cases, both patients securing good function, in which ankylosis was procured by the following method: the atrophic end of the humerus was cut off and the healthy bone above was filed into a square shape. With a fine small frame saw a square slot of the same size was cut in the upper end of the radius and ulna (which usually, he says, are ankylosed at their upper ends). He then implanted the humerus into the slot, and held the bones in apposition by silver wire passed through a drill hole. A gypsum case, including chest and arm, was worn for three months, and a small gypsum case for six weeks longer; and then a sling.

In the first patient I am about to report there was not only marked atrophy of the bones, the consequence of tuberculous disease originating twenty-six years before, followed by an arthroplasty, and then by two excisions of the elbow; but there was in addition paralysis of the ulnar nerve (from operative section), and almost complete paralysis of the median and musculo-spiral nerves, from stretching across the gap between the humerus and forearm bones.

FIG. 2.—Case II. Plastic operation on elbow to maintain flexion, for infantile paralysis.

In the second patient as a consequence of infantile paralysis, there was no power in the entire upper extremity, except feeble flexion of the index and middle fingers. In each case a different method of operation was adopted, to suit the individual requirements; but, in both, raw bony surfaces were kept in close apposition by wire sutures, and prolonged immobilization was employed after operation. Both patients secured bony ankylosis, and considerable improvement in usefulness of the hand.

CASE I.—Margaret H., then twenty-eight years of age, was referred to my service at the Episcopal Hospital in October, 1915, by Dr. Charles H. Frazier. When ten years of age she had developed tuberculosis of the left elbow, and three operations for drainage had been done at various times, the patient finally recovering with ankylosis. In February, 1915, an attempt at arthroplasty had been made (with temporary resection of the olecranon), and during this operation the surgeon unfortunately cut the ulnar nerve. This seems not to have been discovered at the time, since about a month later another operation had been done for suture of the nerve.

When she first came under my care, about seven months after the nerve suture,

she presented a painful elbow with scarcely any motion, and some heat, and with no evidence of regeneration in the ulnar nerve. In October, 1915, I explored the nerve, resecting a long bulb, and transplanting the nerve anterior to the internal condyle of the humerus, a procedure which permitted end-to-end suture of the nerve, and which at the same time removed it from the scar tissue in which it formerly lay.

After an interval of a year no function had been regained in the nerve except perhaps in the sensory distribution. At this time (October 25, 1916) I did a formal excision of the elbow which was still painful and had an extremely limited range of motion. This operation was not successful, since the range of passive motion secured
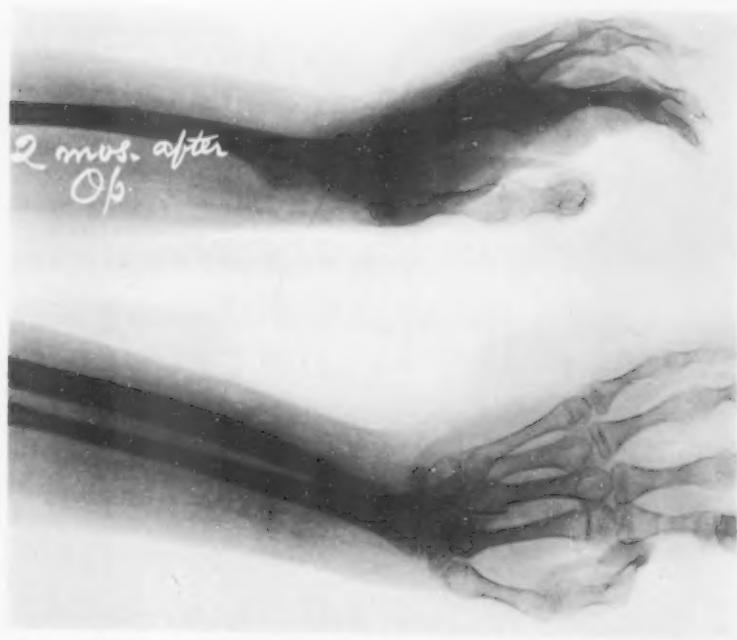

FIG. 3.—Case II. Skiagraph two months after arthrodesis of wrist; bony ankylosis.

was only from 50° to 120°, and practically no active motion was possible, chiefly owing to the extreme muscular atrophy (the elbow had been ankylosed for the previous nineteen years). During my absence in Europe (1917–1919), Dr. A. Bruce Gill, then my assistant, did a re-excision of the elbow, in an effort to increase the range of motion; but the result of this operation was a totally flail joint, over which the patient had not any control whatever. In addition, her disability was soon increased by slowly developed almost total paralysis of the median and musculospiral nerves, probably from overstretching as they crossed the elbow.

In September, 1920, when she came to me again seeking some improvement in her condition, her arm hung limp by her side; there was no active motion at the elbow, though the biceps could be felt to contract feebly. The elbow was utterly flail, and the hand practically useless: there was barely enough power between the thumb and index finger to hold a sheet of paper. The fourth and fifth fingers were in the typical position which follows ulnar paralysis, and there was diminished sensation in the distribution of the ulnar nerve below the wrist. A brace was ordered for her, to keep the elbow flexed and bring her hand up to a position where she would have more incentive

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to use it. This brace, consisting of a socket to the forearm with counter-balancing weights attached to a rod which extended back of the elbow in the plane of the flexed forearm, permitted passive motion at the elbow.

Finally, in 1923, no improvement having occurred, it was determined to attempt to ankylose the elbow at right angles, under the expectation that this would permit recovery of function in the median and musculospiral nerves, and keep the hand where what little power it had would be most useful. But it seemed uncertain whether bony ankylosis could be secured between such atrophic bone ends which had been several inches apart for so many years.

Operation, April 7, 1923, at the Orthopædic Hospital. A longitudinal posterior

Fig. 4.—Case II. Skiagraph two months after arthrodesis of elbow; bony ankylosis.

median incision was made, 10 cm. long, exposing the bone ends, which were just beneath the deep fascia. The humerus was atrophied so that its end was shaped like an osteotome. The radius and ulna, which were of the same length, presented rounded but also very atrophic ends, which moved on each other in rotation of the forearm. The apposing surfaces of the radius and ulna were removed by saw and gouge forceps, making a slot (shaped somewhat like a tuning fork) to receive the humerus. The end of the humerus was then denuded on opposite sides by a saw, and was placed in the slot between radius and ulna. A hole was then drilled through all three bones at once; but as the drill was being withdrawn the end of the humerus broke off. The humerus was then exposed higher up, where less atrophic, and opposite sides of the bone were denuded of periosteum and the cortex roughened by being thoroughly rasped with a saw. The humerus was then replaced in the slot, a hole drilled across it, and a wire passed through all three bones, its ends being twisted down on to the posterior surface of the humerus (Fig. 1). After closure of the soft parts in layers with chromic gut, the elbow was fixed at a right angle and with the forearm in slight pronation, by a plaster-of-Paris dressing, including the entire left upper extremity and chest, the shoulder being in moderate abduction.

June 16, 1923, the first dressing of the wound was made, nearly nine weeks after operation. The incision was firmly healed, and the elbow solidly ankylosed. A splint was worn for many weeks longer, being abandoned first during the day, and finally even at night. By the autumn it was noted that the hand was growing stronger, and eight months after operation the patient had *complete use* of her thumb, index and middle fingers, showing return of power in the median and musculospiral nerves; only the fourth and fifth fingers remained useless.

October, 1925. This woman, now thirty-seven years of age, has practically no disability remaining except the stiff elbow, and the ulnar palsy.

CASE II.—Elwood W., now seventeen years old, first came under my care at the Orthopædic Hospital in 1919, at the age of eleven years with a flail-like left upper extremity, the result of an attack of poliomyelitis when five years of age. This attack had come on a couple of weeks after the boy had fractured his left forearm, and his splints were still in place when the poliomyelitis confined him to bed.

His shoulder was almost flail, the humerus dropping from the glenoid, and being easily subluxated anteriorly. There was not enough power in the biceps to flex the elbow, and no power in the triceps. His hand was useless; he could not pick anything up in it, and could barely hold light articles placed in it. There was no power of opposition between thumb and fingers.

Several minor operations were done on the hand by my associate, Dr. E. T. Crossan, in an effort to secure opposition of the thumb, in 1919, in 1922, and again in 1923; in 1922, also the pronator teres was transplanted to make it function as a supinator. In April, 1920, the so-called Jones operation to keep the elbow flexed was done: this consisted in excision of a large ellipse of skin from the flexure of the elbow, and suturing of the edges of the raw area with the elbow in acute flexion. This held the elbow in flexion for a few months only (Fig. 2) and no power was regained in the biceps.

By August, 1924, he was able to hold many objects between his thumb and fingers. August 28, 1924, arthrodesis of the wrist was done, fixing the wrist in hyperextension. In February, 1925, the wrist was firmly ankylosed at an angle of 200° (20° hyperextension). He was now able to lift utensils with his hand, and found it more useful in every way. The index finger when flexed strikes the end of the thumb nail; the middle finger has feeble flexion but strikes nothing; no motion in fourth and fifth fingers. In June, 1925, the dropping of the humerus from the acromion was more pronounced. It was determined next to arthrodese the elbow.

Operation. June 18, 1925. A median longitudinal posterior incision 8 cm. long was made, splitting the triceps and its insertion in the olecranon. The soft parts were reflected until both epicondyles were bared. The humerus was so atrophic it was easily penetrated by blunt instruments except along the two supracondylar ridges. Both lateral ligaments were cut subperiosteally from their humeral attachments, and the end of the humerus was brought into the wound, and denuded of all cartilage by means of a hand gouge. The head of the radius and the greater sigmoid fossa of the ulna were treated in the same way and the humerus replaced in contact with the forearm bones. A hole was then drilled from the subcutaneous surface of the ulna through the internal condyle to the posterior surface of the latter, and a silver wire was inserted, merely to hold the bones in apposition. Good contact of raw bony surfaces was thus secured. The wound was closed in layers, and the elbow fixed about at an angle of 100°, with the forearm in supination, by a plaster-of-Paris dressing including the chest.

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August, 1925. First dressing; ankylosis solid. Hand decidedly stronger and more useful.

October, 1925. The arthrodesis of the thumb in opposition has brought it into a position where the index finger strikes it during flexion: the arthrodesis of the wrist in hyperextension has placed the hand in a useful position on the forearm and has transferred the feeble power of the flexors directly to the fingers, relieving them of any duties as concerns the wrist; and the arthrodesis of the elbow in flexion keeps the hand up where it is possible for it to be of use in the world. Perhaps sometime later an arthrodesis of the shoulder will provide for motion of the whole upper extremity through the action of the trapezius, which is strong.

REPAIR OF WOUNDS OF THE FLEXOR TENDONS
OF THE HAND*

By John H. Garlock, M.D.
of New York, N. Y.

Within recent years, considerable interest has been aroused in the problems connected with the surgery of the flexor tendons of the hand. This has been due, in great part, to a more careful inquiry into the ultimate end results and also to a thoughtful study of the minute anatomy of the structures and the physiological principles involved in their function. Until very recently, the anatomical and functional end results of surgically treated lesions of the flexor tendons, judging from the reported cases and from impressions gained through personal inquiry, have been notoriously poor. When critically analyzed, it is found that there are many reasons for this. In the first place, a frequent error has been the injudicious application of a set operative procedure. A common example is the operative repair of a divided tendon in the presence of an obviously contaminated wound of the superimposed soft parts. Secondary infection with sloughing of part of the tendon is not an infrequent result. Improper operative technic is another common cause for poor end results. In the surgical treatment of flexor tendon injuries, extreme nicety of detail, minimum tissue trauma and great patience are prime requisites. Again, a technically perfect operation on a flexor tendon is of little use to a patient when ultimate function is considered, if the interphalangeal joints moved by that tendon are stiffened and immobile. The same criticism applies to those cases where the tendon sheath has either sloughed or become fixed to the tendon as a result of infection and no attempt is made at operation to reconstruct a new gliding mechanism.

A good result can scarcely be expected when a tendon is repaired in the presence of atrophic or fibrous or sclerosed soft parts. Difficult problems present themselves here and the preliminary reconstruction of the skin and subcutaneous tissues by the use of full-thickness grafts becomes an important and necessary step in the satisfactory progress of the case. Finally, poor results can be expected uniformly when the post-operative care is carelessly carried out.

In attempting to systematize and analyze end results, it soon became evident that it was necessary to adopt some working classification which would incorporate every type of tendon injury. It seemed hardly fair to compare the end results of simple, single, primary tenorrhaphies with the cases requiring reconstruction of the soft parts and tendon grafting. As the work progressed the following classification suggested itself:

A. *Immediate Primary Tenorrhaphy.*

B. *Early Secondary Tenorrhaphy.*

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* Read before the Surgical Section of the New York Academy of Medicine, October 2, 1925.

In this group, the tendon repair is attempted after the initial wound of the soft parts has healed. Every case within the arbitrarily selected period of four to six weeks following the injury falls under this heading.

C. *Late Secondary Tenorrhaphy.*

Every case operated upon later than six weeks after the original injury comes in this group.

D. *Late Secondary Tendon Repair with Reconstruction of the Soft Parts.*

It can readily be seen that a variety of conditions would be included here. The more important and those most frequently encountered, present either loss of the tendon sheath or adhesions between tendon and sheath as a result of trauma and infection or atrophy and fibrosis of the soft parts. Any combination of these pathological conditions can be found in the same case.

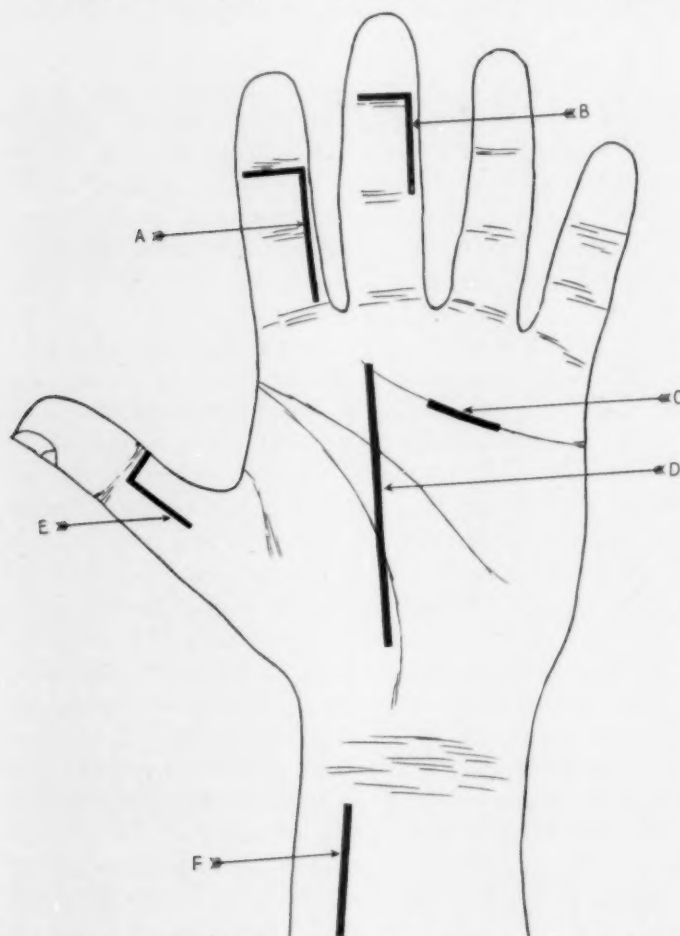E. *Tendon Grafting.*

Before taking up the treatment

Fig. 1.—Diagrammatic sketch representing the various incisions used in exposing the flexor tendons for operative repair. A. Inverted L-shaped incision with long arm for exposing divided flexor profundus and sublimis tendons. B. Incision for exposing divided flexor profundus tendon. C. Transverse incision in palm for exposure of the retracted proximal end. D. Longitudinal incision made to one side of the tendon when the lesion is situated in the palm of the hand. E. Incision for exposure of divided flexor longus pollicis near its insertion. F. External lateral incision for exposure of the retracted proximal end of the flexus longus pollicis tendon.

of each group, consider a few basic principles which must receive general application in all tendon work. The operative technic should be practically faultless. Not only must asepsis be rigid and complete, but the handling of all the tissues must be carefully done. It was Bunnell who originally described an "atraumatic technic" and made it particularly applicable to tendon surgery. Even with the best asepsis, trauma applied

to tissues will, in an appreciable number of cases, furnish the necessary conditions for the few unavoidable organisms present to cause infection. Aside from trauma, other factors that determine infection are: heavy catgut, large knots, dead spaces, tension of sutures, mass ligation, too many stitches, foreign bodies in fat, closure with incomplete hæmostasis, use of very hot sponges and drying of the tissues due to prolonged exposure. Realizing,

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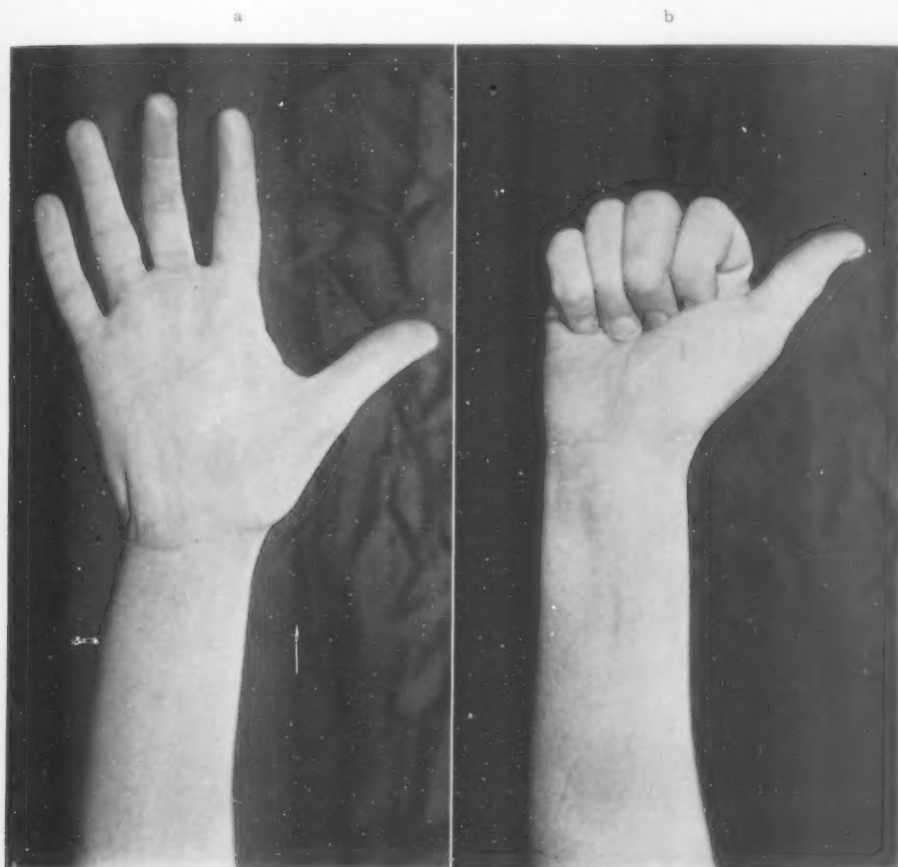

FIG. 2.—M. G. Traumatic division of the flexor profundus tendon of the right middle finger, one cm. proximal to its insertion in the distal phalanx. Operation performed thirteen days after injury at which time the wound of the skin was completely healed. *Operation:* Esmarch bandage, inverted "L" incision, the horizontal limb corresponding to the distal flexion crease. Tendons sutured with silk according to the Bunnell technic. The photographs, a and b, indicate the result at the end of one year.

therefore, that unless great attention is paid to minute details in technic, infection or fibrosis with a firm unyielding cicatrix will result, what should be the conception of an atraumatic technic? We should maintain a wholesome respect for tissues and keep our mind always on their post-operative reaction. To avoid the trauma of sponging, a bloodless field obtained by the use of an Esmarch bandage or blood-pressure cuff is indicated. Sharp dissection, sharp scissors, knives and needles, accurate hæmostasis with fine hæmostats, the use of very fine ligature material, reducing the time of opera-

tion to a minimum, good team-work, conservation of movements by careful study and planning beforehand; these are but a few of the factors to be considered in the attainment of an atraumatic technic.

In the later secondary tenorrhaphies and the reconstruction cases, it must not be forgotten that absolute freedom of mobility in the finger joints is assured before any operative interference is attempted. One should not
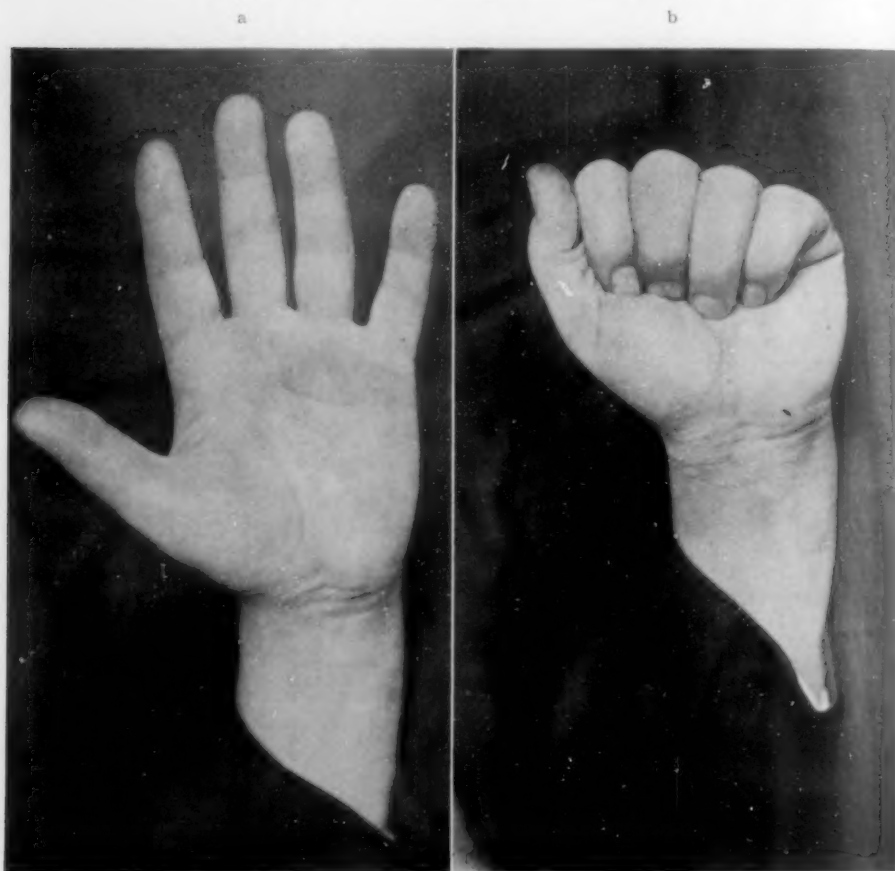
a   b

FIG. 3.—L. F. Traumatic division of both flexor tendons of the left middle finger, the point of division being in the region of the outer end of the distal flexion crease of the palm. Operation performed six weeks after injury revealing completely divided tendons with an organizing hæmatoma stretching between the divided tendons. *Operation;* Esmarch bandage, longitudinal incision on the inner side of the anatomical situation of the flexor tendons, suture of the divided tendons with silk, according to the Bunnell technic. Active motion started on the eighth post-operative day. Photographs, a, and b, show the result at the end of one year.

hesitate to employ every remedy at his disposal in order to obtain this necessary joint pliability. In this connection, it has become evident that a great deal can be accomplished by the judicious use of " home-made " aluminum or buckle splints, utilizing the principle, as we have termed it, of gradual compressive splintage. This applies particularly to the metacarpo-phalangeal and proximal interphalangeal joints.

When we come to consider the treatment of cases falling into Group 1, as

outlined above, one issue of paramount importance arises and must be decided immediately. That is the character of the wound, of the skin and the subcutaneous tissues and the procedure to be adopted. In the presence of a clean incised wound within the initial twelve hours following the injury, immediate tenorrhaphy can be done with safety, after appropriate cleansing. When the wound is ragged and dirty, obviously grossly contaminated, and the surrounding skin is covered with grime and dried blood, it is the writer's opinion that the tenorrhaphy should be deferred until the wound has healed, the immediate interference consisting solely of a general cleansing and débridement. The impression has been gained that the end results have been better since adopting this principle. Certainly, this delay of two or three weeks has not given rise to any demonstrable increase in fibrosis or adhesion formation, nor has it rendered the secondary repair more difficult.

The site of the skin incision depends, in general, upon the point at which the tendon was divided. *It should never be made directly over the tendon,* because the scar will become adherent to the tendon sheath. Permanent impairment of function is almost sure to follow if the incision in the fingers is a median longitudinal one. This incision should be condemned here as well as in the treatment of suppurative tenosynovitis of the flexor tendon sheaths. In the palm it matters very little whether the incision is longitudinal or transverse. The advantage of the latter is that it can be placed in the transverse creases. In the fingers, however, experience has shown that a long continuous side incision, while anatomically and cosmetically correct, has a tendency to contract and pull the finger down slightly into flexion. Although this produces only very slight deformities with excellent function, in an effort to avoid it and obtain a more ideal result, the incisions shown in Fig. 1 were devised. It will be noted that this incision has the shape of an inverted " L," the long arm extending along the side of either the middle or proximal phalanx and the short arm corresponding to one of the flexion creases. The triangular flap thus produced is dissected away from the tendon sheath and a good exposure is obtained.

To preserve the mechanism of a tendon pulling around three corners, thus avoiding a bow-string effect, one must never cut the little pulleys, which are really thickenings in the tendon sheath at the interphalangeal joints. In fact, it has been found distinctly advantageous to avoid as much as is commensurate with obtaining a good repair cutting any part of the tendon sheath. To accomplish this, a separate incision is made over the approximate location of the retracted proximal end and through the distal original wound of the tendon sheath a looped strand of silk-worm gut is passed proximally until it reaches the retracted tendon. A small transverse incision is made in the sheath at this point, the silk suture is placed in the tendon and the silk-worm gut is tied to this suture which is now pulled distally with its attached tendon through the intact sheath as far as the original wound. The tenorrhaphy is now completed.

In the ideal repair of a tendon, a number of requirements must be met.

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1. Trauma must be eliminated.   2. The sutures should be so placed as to leave a minimum of suture material on the surface of the tendon.   3. The knots must be buried.   4. The divided ends must be brought into accurate apposition.   5. The suture material must be of great tensile strength.   6. The sutures must be so placed that a considerable amount of tension may be put upon them without causing them to pull out.   The Bunnell tendon clip dis-

a   b
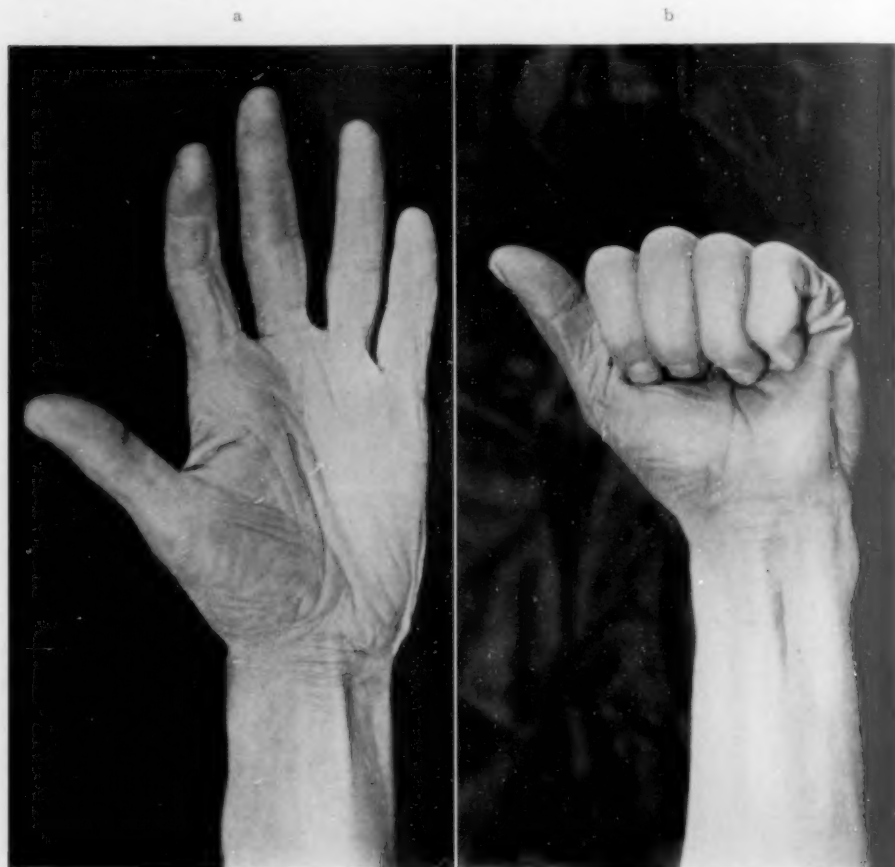

FIG. 4.—A. R.   Divisions of flexor tendons of the left index finger by a buzz-saw in the region of the proximal flexion crease.   Operation performed three hours after injury was sustained and consisted of débridement and primary suture of divided structures.   Tendons repaired with silk according to the Bunnell technic.   Active motion started on the seventh post-operative day.   Photographs, a and b, indicate result four months after injury.

tinctly aids in fulfilling these requirements.   Combining their use with fine silk of high tensile strength and very fine short straight needles, a satisfactory repair can be obtained.   Following the tenorrhaphy, the incisions in the tendon sheath should be closed with very fine catgut.   Where the sheath, of necessity, has been opened wide, this is very often extremely difficult.   The important point to bear in mind is to avoid traumatizing the synovial surface of the tendon sheath by numerous needle punctures.

As to after-treatment. How long should the part be immobilized?   It

has been our custom to immobilize the repaired finger in acute flexion with the wrist in flexion, using a very light plaster glove, for a period of from five to ten days, depending upon the intelligence and spirit of coöperation of the patient. At the end of that time, the glove is removed and active motion within the limits of pain instituted. Inasmuch as prolonged immobilization almost surely fosters the formation of adhesions, it is important to begin

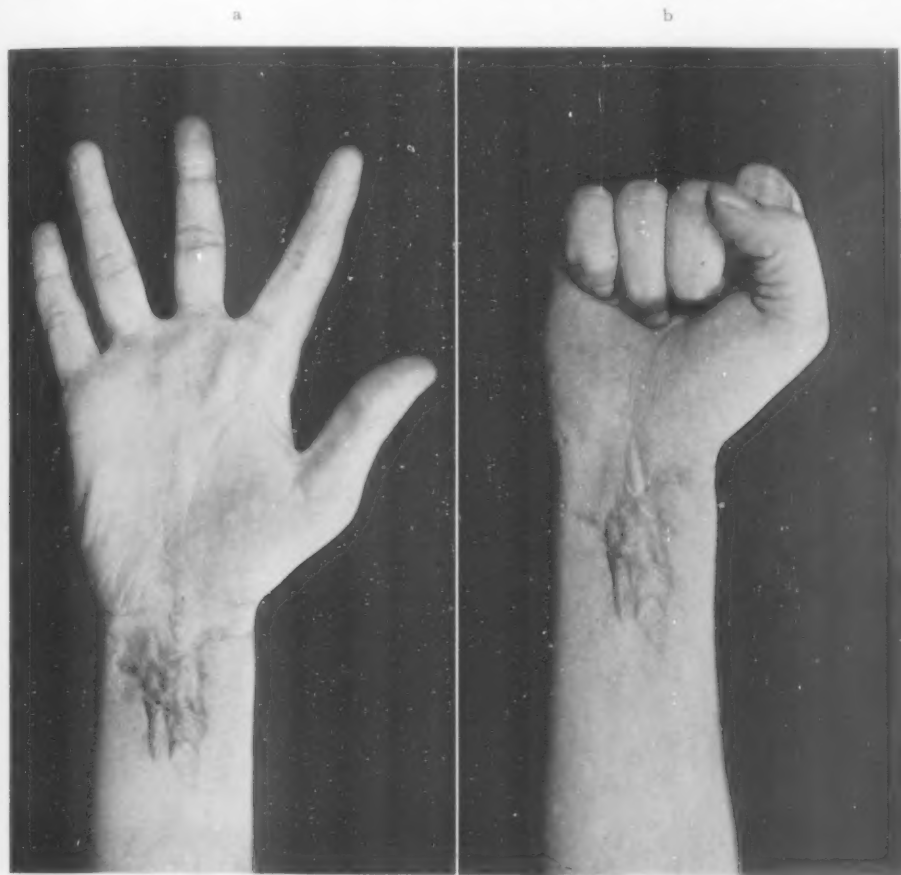a   b

FIG. 5.—L. R. Traumatic division of structures at front of right wrist. Structures divided were the following: Median nerve; ulnar nerve; palmaris longus tendon; flexor sublimis digitorum tendons; flexor profundus tendons; flexor carpi radialis tendon; radial artery. Operation performed three hours after injury, consisting of a débridement and primary suture of divided structures. Silk was used in repair of the tendons. The nerves were repaired by inserting peri-neural sutures of fine silk. Aside from a mild superficial skin infection, convalescence was smooth. Active motion was started on the tenth post-operative day. Photographs, a and b, indicate result at the end of one year.

motion early. To diminish the possibility of placing too much tension on the suture line, the hand is held in acute flexion by a check-rein adhesive arrangement running from the hand to the forearm. This does not prevent active flexion and extension of the fingers, but does diminish the intensity of contraction of the muscles. It is necessary to wear this check-rein for four to six weeks, at the end of which time union will have become firm. After this period, many other remedies may be utilized, as frequent strong galvanic

stimulation of the muscles to produce strong contraction, thus helping to break tiny adhesions, scientifically applied baking and massage, hot soaks, whirlpool baths, re-education exercises, passive motion, etc. While we do not question the value of these procedures and constantly make use of them, it is felt, that more can be accomplished by carefully controlled and personally encouraged active motion in the initial six or eight weeks of treatment. The time element must also be considered as having a direct bearing on the eventual outcome, inasmuch as an optimum result may not be obtained until a period of four to six or more months has elapsed.

When the flexor profundus tendon has been divided at or near its insertion in the base of the distal phalanx, the repair is difficult and the end results, as a rule, are only fair. This is probably due to the fact that because of the shortness and inaccessibility of the distal segment, considerable trauma is caused in placing the sutures and an accurate end-to-end apposition thus diffi-

PRIMARY TENORRHAPHIES—18

Site o injury		Good	Fair	Poor
Near insertion of profundus tendon...	6	2	1	3
Over middle phalanx..............	2	1		1
At proximal phalanx (both tendons)..	2	1	1	
In palm..........................	6	5	1	
At wrist..........................	2	1	1	

FIG. 6.—Chart of end results of 18 primary tenorrhaphies.

cult to obtain. Obviously, dense adhesions soon form and motion is greatly limited. Since the principle of avoiding longitudinal incisions in the tendon sheath was adopted, the impression is gained that the functional results in this type are better.

The cases falling into Group 2 of the above general classification are treated essentially along the same lines. Occasionally, it will be found that where mild infection has preceded the healing of the wound of the soft parts, a firm cicatrix has resulted. Or dense scar tissue may result from an extensive traumatizing laceration. In such instances, operative treatment includes excision of the scar, freeing of the tendon sheath, the insertion of a free fat transplant from the triceps fascial region, a plastic repair of the skin or a pedicled skin graft, the prime reason for these procedures being the prevention of new scar tissue formation about the tendon sheath. The indications for, and the limitations of the use of such methods, must be considered carefully in each case.

When repair of divided tendons is attempted at any time later than the initial six weeks following the injury, i.e., in the later secondary cases, additional conditions are found which must be dealt with. The proximal end of the tendon will be found retracted to its farthest point and usually inti-

mately adherent to its sheath by scar tissue. Or it may lie free in its sheath, but showing a curled-up, friable atrophied end. Very often, however, it will be found that the ends of the tendon are lying free in the sheath, which itself is smooth and glistening, all structures appearing quite normal. All degrees and gradations of secondary changes may be encountered up to the extreme type where a mass of dense scar tissue extends between the two ends of the tendon, binding all structures together into a firm cicatrix. The operative treatment depends upon the extent of the conditions found. In the simple cases, without scar tissue, tenorrhaphy may be done according to the principles already outlined. The bulbous tip of the retracted proximal segment can be excised and very often sufficient tendon remains to allow of a satisfactory repair. To free a tendon adherent to its sheath, use is made of a tendon stripper, an instrument originally described by Bunnell. The adhesions that form following such a procedure must be relieved by a second operation.

EARLY SECONDARY TENORRHAPHIES—10

Site of injury		Good	Fair	Poor
Near insertion	4	3	1	
Middle phalanx none				
At proximal phalanx (both tendons)	1		1	
In palm	4	3		1
At wrist	1		1	

Fig. 7.—Chart of end results of ten early secondary tenorrhaphies.

Although not ideal, good results have been obtained. When the repair is done in the region of the palm and there has been a loss of part of the tendon sheath, a gliding mechanism must be created to prevent the reformation of adhesions. This is best done by encircling the exposed part of the tendon by a sleeve of free fat graft. This fat must have definite gliding properties (paratenon) and is exemplified best by the fatty tissue over the triceps tendon. If, however, the lesion is located in the finger proper, it will be found that this procedure cannot be carried out because of the limited space. Under these circumstances, judging from the writer's limited experience and certainly from the sanguine reports of Bunnell and others, it seems feasible to excise the exposed portion of the tendon and insert a free tendon graft (taken from the extensor tendons of the toes) with its encircling sheath, care being taken not to divide the little pulleys in the region of the interphalangeal joints. Here again, as in Group 2, any abnormalities in the superimposed soft parts must be accorded separate attention before a good result can be expected.

Those cases (Group 4) with more or less extensive pathology in the skin and subcutaneous tissues in addition to lesions in the tendons and their sheaths present interesting problems. There may be fibrosis and atrophy of the subcutaneous tissues with cicatrization of the skin, due either to extensive

trauma, or an old infection, or the use of the ill-advised median longitudinal incision. The so-called flexion-contracture is a common example in point. Before attempting any operative treatment, one must be sure that the joints are fairly pliable. This may be obtained by the judicious use of splints, following the principle of gradual stretching and avoiding violent brisement forcé under anæsthesia. A finger that is permanently stiffened had better be amputated. It is obviously wiser to first replace the sclerosed soft parts by healthy tissue before attempting any operative work on the subjacent tendons. The contracting scar tissue is, therefore, excised and the finger is fully extended, cutting the capsule of the joints, if necessary, to accomplish this. The finger is then immobilized on a previously prepared sterilized metal splint. A tubularized pedicled graft, made ten to twelve days before on the chest or abdomen, is then sewn over the raw area. The objections to the free full thickness or Wolfe grafts are: 1. That there must be perfect and complete

LATE SECONDARY TENORRHAPHIES—6

Type of case	Good	Fair	Poor
3 months after injury, near insertion of profundus.................... 1			1
7 weeks to 4 months suture with fat transplant (palm)............... 3	2		1
8 weeks and 3 months. Suture after use of tendon stripper (palm)...... 2	1	1	

FIG. 8.—Chart showing end results of 6 late secondary tenorrhaphies.

immobilization. 2. That there must be firm even pressure applied over the grafts to prevent any accumulation beneath them, a difficult thing to accomplish in the fingers, and 3. That the Wolfe grafts have a great tendency to become pigmented. Thiersch grafts are inadequate for this purpose because they do not supply enough tissue.

After the graft has taken, the pedicle is cut away and the cut end is then sewn in place. Before undertaking any work upon the tendons, one must wait until all possibility of latent infection and all post-operative induration has disappeared, probably three or four months. Only by so preparing a suitable field is it possible to free adherent tendons, repair tendons or insert tendon grafts without fearing the reformation of adhesions. The principles as outlined may be applied to any part of the hand, the important point being that skin reconstruction and tendon work cannot be done at one and the same time, as a general rule.

The question of tendon grafting calls for a clear understanding of the anatomy of tendons and their surrounding structures. This has been carefully worked out by Mayer, of New York, and by Biesalski, who emphasized so well the importance of the gliding mechanism. Briefly their findings are as follows: When a tendon pulls in a straight line, it is encircled by loose fatty tissue called paratenon, which is pulled back and forth in its central

zone with movements of the tendon. When a tendon pulls around a corner, it is enclosed in a tendon sheath, in which the surface of the tendon (epitenon) moves freely within the synovial lining of the sheath. This is found in the hand. In other parts of the body a blood-vessel-bearing mesotenon is present, being attached to the side of the epitenon opposite the side of friction. In the hand the mesotenon is represented by the attenuated structures, the vincula tendineæ (Ligamenta breva and Ligamenta longa). With this picture of the anatomy in mind, the main indication in all tendon work is clear, *i.e.*, to maintain the old or supply a new gliding mechanism.

When, upon exposing a tendon and its sheath that have been the seat of infection, it is found that these structures are glued together by adhesions, one of three procedures may be undertaken. If the adhesions are not very firm or extensive, the tendon may be freed by the use of a tendon-stripper, active motion being instituted immediately. Very often a complete return

TENDON PLASTIC WITH SKIN RECONSTRUCTION—7

Type of case	Good	Fair	Poor
5 flexion contractures, 2 due to trauma, 3 due to infection	2	2	1
Scars in palm—adherent tendons and loss of tissue........... 2		1	1

FIG. 9.—Chart showing end results of 7 cases of tendon plastic operations with skin reconstruction. The chart is self-explanatory.

of function is noted. Secondly, if the pathology is more pronounced in the palm proper, the tendon can be freed by the stripper and a paratenon type of gliding mechanism imitated by inserting sleeve-like about the roughened tendon, a free fat graft taken from the triceps region. Or the involved part of the tendon can be excised and a free graft from the palmaris longus tendon with its surrounding paratenon inserted. When such grafting is done in the proximal half of the palm or in the forearm, the possibility of adhesion formation is less and results are good. When it is done in the distal half of the palm and the fingers, there is rarely return of complete function. Such being the case, it seems feasible to imitate the conditions found in the normal hand, by inserting free grafts of tendons with their respective tendon sheaths. The best source of such grafts can be found on the dorsum of the foot, namely, the tendons of the extensor communis digitorum. The extensor brevis-digitorum takes up whatever function that may be lost by the removal of such grafts and toe drop does not occur.

In performing the grafting, it is necessary to free the old tendon by planing it away with the stripper, care being taken not to injure the pulleys of the old tendon sheath. If the flexor sublimis tendon itself is diseased or in the way, it should be removed. It is not necessary to attempt to replace this tendon because it is not needed for function and because the procedure then becomes too complicated. Indeed, this tendon may sometimes be used as the

source of a graft when it is free of pathology. The sutures are placed in the ends of the graft which is then pulled through the old sheath, surrounded by its own normal theca. The graft is then united to the ends of the old tendon and the new sheath is sutured. In all tendon grafting, the principle, as determined by Mayer, of the proper tension for uniting a tendon must be followed. When the origin and insertion of a muscle are approximated as close together as possible, the tension of the tendon should be zero, the only exception being in the case of a muscle, which, owing to division of its tendon, has long been contracted.

The after-treatment is, of course, most important. Active motion should not be started as early as in the simple tenorrhaphies because two suture lines have been made, thereby producing two weak points instead of one. Then, again, foreign tissue has been introduced and it is questionable if too early motion is entirely beneficent. Carefully controlled and personally directed

TENDON GRAFTS—4

Type of case	Good	Fair	Poor
Free graft of palmaris longus tendon in palm.......................... 2	I	I	
Free graft of flexor sublimis tendon.... I			I
Free graft of extensor communis digitorum in foot................... I		I	

FIG. 10.—Chart showing the end results on 4 cases of free tendon grafts. The chart is self-explanatory.

motion may be instituted after fourteen days, gradually increasing its range day by day.

The accompanying charts indicate clearly the functional end results obtained in a series of forty-five consecutive tendon cases, illustrating varying degrees of pathology. An examination of Figs. 6 and 7 would seem to indicate a paradoxical discrepancy in the end results of those cases where the flexor profundus tendon was divided near its insertion. That is, in the primary group, of six cases, three were classified as poor, whereas in the early secondary group of four cases, three were good and one was rated as fair. This is due to the fact that in the early secondary cases a short inverted " L "-shaped incision was used instead of the long lateral one, thereby diminishing the amount of trauma. In addition, most of the primary tenorrhaphies were done before the inverted " L "-shaped incision was adopted. It will be also noted that the best results are obtained in those cases where the point of division is in the palm of the hand.

A SKIN FLAP COVER FOR PROJECTING INTESTINE*

By Moses E. Steinberg, M.D.

of Portland, Oregon

THE various methods for bringing the hollow viscera to the outside of the abdominal wall as permanent therapeutic or experimental fistulæ are not without shortcomings. The many operations for a colostomy have the drawback that they open on the same plane with the skin of the abdominal wall.

FIG. 1.—Initial skin incision.

The colostomy cup has no means of anchoring itself at the artificial anus, allowing the fecal contents to escape between the cup and the abdominal wall. This condition becomes aggravated if the fæces are soft or liquid, the skin being soiled for a large area about the colostomy opening. The patient with a permanent gastrostomy or a permanent jejunostomy opening is always more or less annoyed by the erosion of the surrounding skin from the escape of stomach or intestinal contents. The enumerated disadvantages also apply to the experimental fistulæ in animals performed for the purposes of research. The collection of the contents escaping from the fistulæ is at times quite difficult to carry out due to the fact that some of the contents escape outside of the collecting tube, resulting in faulty experimental data.

Hoping to eliminate some of the objectionable features encountered in producing the various fistulæ, an attempt has been made to bring the hollow viscera outside of the abdomen in such a manner as to cause a permanent protrusion beyond the plane of the abdominal wall. The peritoneal lining of the viscus is surrounded with flaps of skin.

FIG. 2.—Incisions to form the skin flaps.

A brief description of the technic used in performing six permanent colostomies in dogs will be here given. The initial skin incision may correspond to the peculiar conditions of a given case. In our experimental work we used the left rectus incision. After exploration the descending colon is delivered and severed in the usual aseptic technic. The proximal and distal loops are closed by ligature and purse-string suture, carefully avoiding injury to the blood supply of the bowel. The distal loop is thrown back into the abdominal cavity and the proximal loop with its mesenteric attachment is
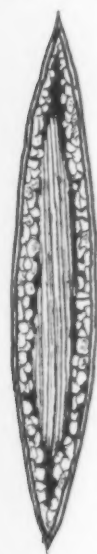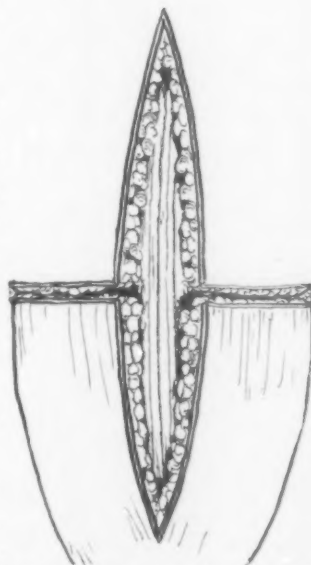
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* From the Department of Physiology of the University of Oregon Medical School.
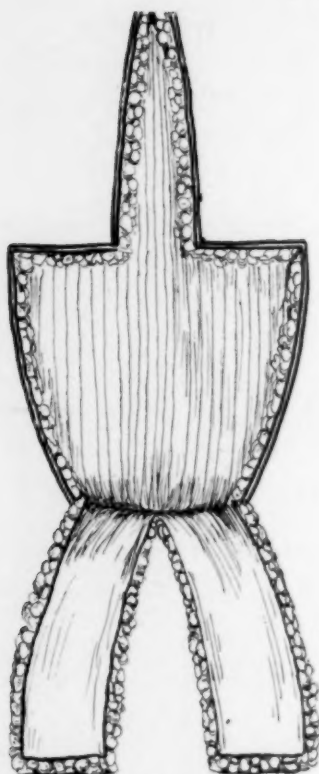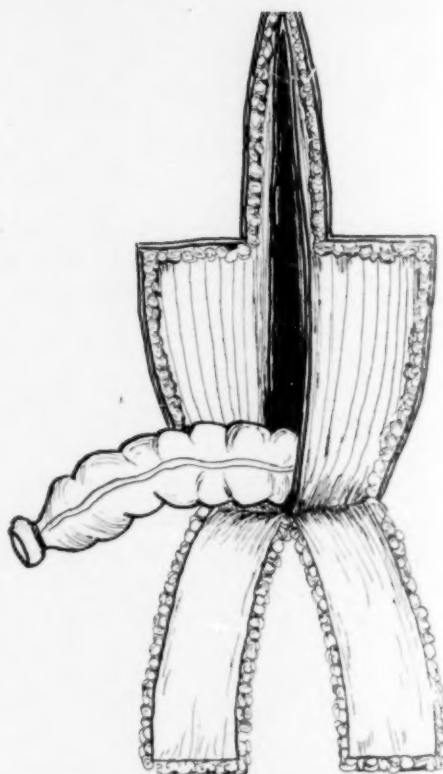
FIG. 3.—Skin flaps dissected and reflected.
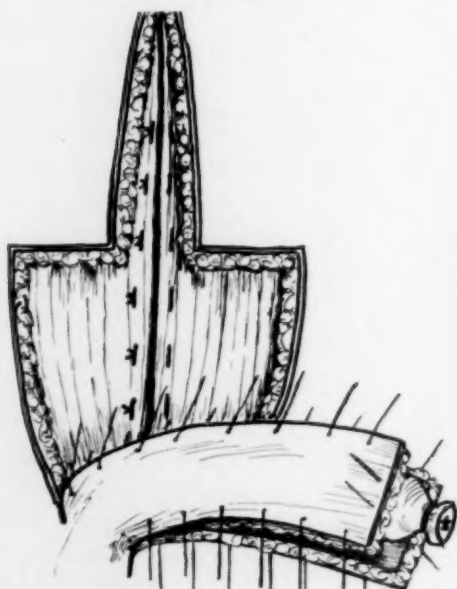
FIG. 4.—Large bowel delivered to the outside.

FIG. 5.—Peritoneum muscle and aponeurosis of operative wound closed. Skin flaps made to surround protruding bowel.
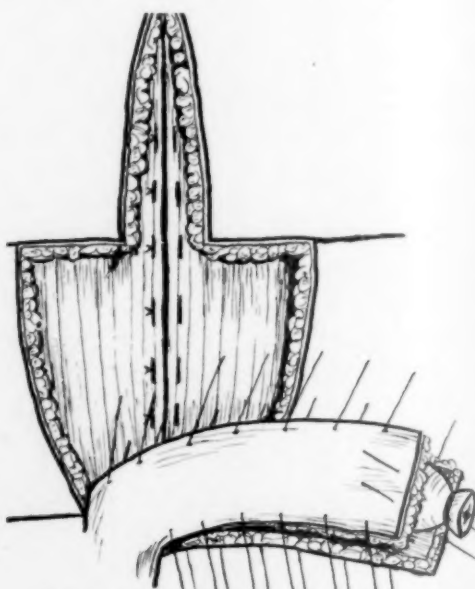
FIG. 6.—Skin is undermined along incisions perpendicular to the initial incisions in order to close the skin defect in the abdominal wall.

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kept outside and made to protrude for five or six centimetres beyond the plane of the abdominal wall. The skin flaps which surround the protruding viscus are fashioned from the initial exploratory incision in the way depicted in the accompanying illustrations (Figs. 1 to 7). The colostomy is not opened until three or four days later when the superfluous bowel uncovered by skin is removed with the cautery.

So far no opportunity has presented itself to perform this method of colostomy on a human subject. It will have its limitations since it may not lend itself to easy performance when the bowel is inflamed and actually distended. Its performance would only be possible where the mesenteric attachment of the bowel will permit its delivery from the abdominal cavity. From the experiments on animals it appears that the performance of this type of colostomy should not be complicated on the human being. It should heal easily and offer better artificial control of the anus. Pressure with gauze and adhesive should be sufficient to control the colostomy opening. The colostomy cup can be applied when necessary over the protruding bowel in the same manner as a urinary

FIG. 7.—Operation complete.

bag is applied over the penis in urinary incontinence. The skin flap method is suggested for the following clinical or experimental fistulæ: Colostomy jejunostomy, gastrostomy, œsophagostomy, fistulæ for experimental research.

We are now engaged in working out the technical details in the methods of performance of these fistulæ and shall report on the work in due time.

Our work on this problem has started over a year ago. Lately our attention has been called to an article in *La Presse Médicale*, No. 12, February, 1925, by Prof. O. Lambert. There one finds a description of an artificial anus somewhat similar to the one described in this article.

I wish to acknowledge the kind assistance of Tom Wyatt in connection with this work.
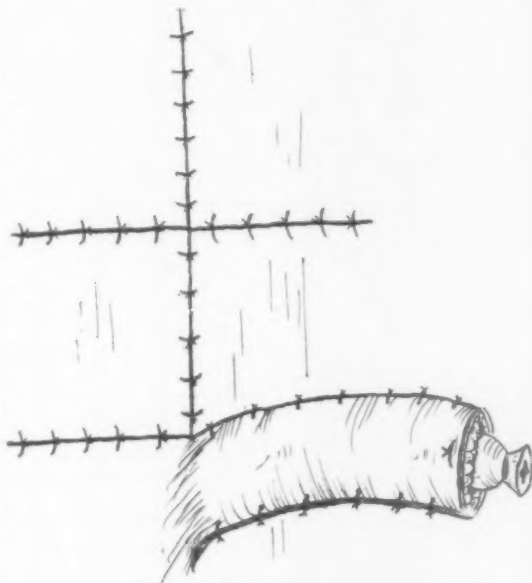
A PERINEAL ELEVATOR

By CHARLES Y. BIDGOOD, M.D.

OF HARTFORD, CONN.

IT HAS often been emphasized that one of the most important factors in the facilitation of perineal surgery is having the patient in the correct position, *i.e.*, with the perineum parallel to the floor. Success in attaining this exaggerated position requires that the pelvis be elevated and flexed, and that the thighs be flexed on the abdomen.

If prostatic and seminal vesical surgery is attempted with the perineum in a position of less elevation than this, the technical difficulties of any operation are immediately increased, because the laxity of the central tendon, and the transversus perinei and recto-urethralis muscles obscures these important landmarks, thereby rendering the approach to the prostate and seminal vesicles more difficult, and more hazardous, in so far as injury to the rectum is concerned. It is quite possible that failure to recognize these facts has helped to earn for the perineum the undeserved reputation of being a difficult operative field, with the result that it is generally avoided, and that some operations in this region have not attained the popularity to which their merit entitles them.

Although combined cystoscopic, X-ray and operating tables, with a perineal elevator attached, as, for instance, the table of Hugh Young, are in the market affording an complete and efficient mechanism, most surgeons, are not fortunate enough to possess one of these tables, and are compelled to use the ordinary operating table, with the patient in the usual lithotomy position, which is very inadequate, or the Halsted board, which is better, but not ideal.

The elevator illustrated here was therefore constructed to fulfill the following requirements: (1) To give the maximum degree of elevation. (2) To be attachable to any operating table. (3) To be light, so that it can be easily carried from one operating room to another. (4) To be simple and strong in its construction.

It is composed of two parts, the elevating mechanism (Fig. 1), and the leg pieces for flexion of the thighs (Fig. 2).

The sketch (Fig. 1) illustrates the elevating mechanism. It is composed of the steel footpiece (1), which is one inch high, and six inches wide. Attached to each end of this footpiece is a half round steel track (2), extending backward thirty-six inches. To the footpiece (1) are also attached two adjustable hooks (3), whose function is to grasp the flange at the end of the operating table, thereby immobilizing the apparatus. Projecting outward one inch from the centre of the footpiece is the crank end of the screw (7). The elevating planes (4 and 5) are made of aluminum, and are so constructed that when the anterior plane (4) is elevated until it is

perpendicular to the level of the operating table, the posterior plane (5) is at an angle of 45 degrees to it. The anterior plane (4) is hinged to the footpiece (1). The posterior plane is equipped on the under surface, at each

corner, posteriorly, with a runner (6), which fit the steel tracks (2), so that when the plane is elevated, it slides over the tracks.

The screw (7), extends backward underneath the elevating planes and is threaded through the small steel block (8). To each end of this block is hinged a steel strip (9). These extend backward and are hinged at their other ends to a steel block which is fastened to the under surface of the edge of the posterior plane (5). The space between the strips (9) receives the screw (7) when the plane (5) is drawn up, so that it never projects from underneath the edge of the plane. The patient is, therefore, never endangered by it. The small upright (10), which is one inch high, serves to give the planes the necessary initial break, and to prevent their sagging under the weight of the patient.

The mechanism for b r a c i n g t h e shoulders consists of an aluminum cross-piece (11), which is two inches wide, and which is deeply notched at each end, so that the upright shoulder braces (12), can be detached when desired, and can be adjusted to the width of the patient's shoulders. On the under surface of the piece (11) are attached runners to fit the tracks (2). In the centre of the cross-piece (11), there is turned down from the anterior and posterior edges a flange (13), which has a slot cut in it. Through these slots is run the flat steel strip (14). This strip is hinged at one end to the block on the under surface of the posterior plane. Its posterior half is perforated by holes

FIG. 1.—Elevating mechanism for exposing perineum.

one inch apart. These holes are to receive the steel pin (15). By this arrangement, the shoulder braces can be adjusted to the length of the body, and held in the proper place by the pin being placed in the hole pre-
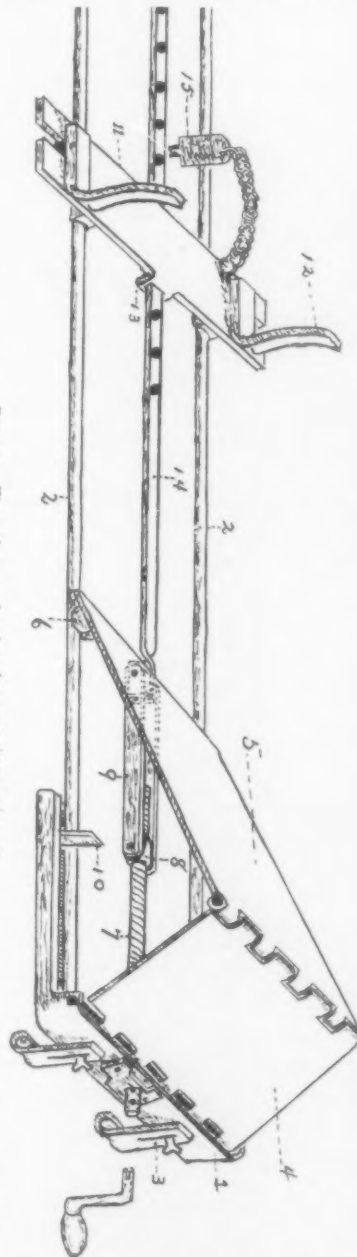
senting behind the cross-piece (11). Also, the attachment of the strip (14) to the posterior plane causes the shoulder braces to be pulled up as the plane is elevated. This is necessary because it prevents the elevating planes from slipping from underneath the buttocks as they rise; the result being that the patient is really pulled up into position.

The mechanism for flexion of the thighs is shown in Fig. 2.

The mechanism controlling the action of the leg pieces consists of the steel part (1), which is shaped like a tuning fork. The downward projecting rod (2), which corresponds to the handle of the tuning fork, is made to fit into the Bierhoff clamps that are found on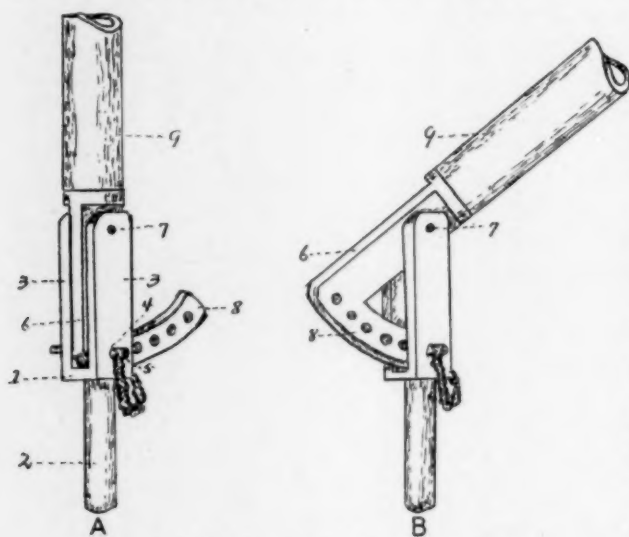 all operating tables. The uprights (3), are perforated near their base by the hole (4), into which the steel pin (5), is made to fit.

Between the uprights (3) is dovetailed the piece (6), which is hinged at the point (7). Projecting backward from the lower edge of this piece is a flange (8), which is perforated so that the holes in it coincide with the holes in the base of the uprights (3). To the

FIG. 2.—Leg pieces for flexion of thighs. See also Fig. 4.

upper end of the piece (6) is attached a pipe (9), which is thirty inches high. (This is cut down in the sketch.)

Figure 3 shows the pipe in the upright position, and figure 4 shows it dropped back 45 degrees, and held in position by the pin (5) passed through the holes near the base of the uprights (3), and the coinciding hole in the flange (8).

Method of Operation.—The elevator is placed on the operating table with the planes lowered, and the hooks adjusted to engage the flange of the table. (Fig. 3.) The patient is then placed on it, and the shoulder braces adjusted to the length and width of the body. The pin is then dropped into the hole presenting behind the cross-piece which holds these braces.

The leg pieces are then placed in the Bierhoff clamps and made fast, with the bars in the upright position. The patient's thighs are flexed, and the legs placed around the bars, which are then pushed back as far as possible, and fixed in this position, as described in Fig. 2-B. The footpiece of the operating table is then lowered, and the pelvis elevated by attaching the
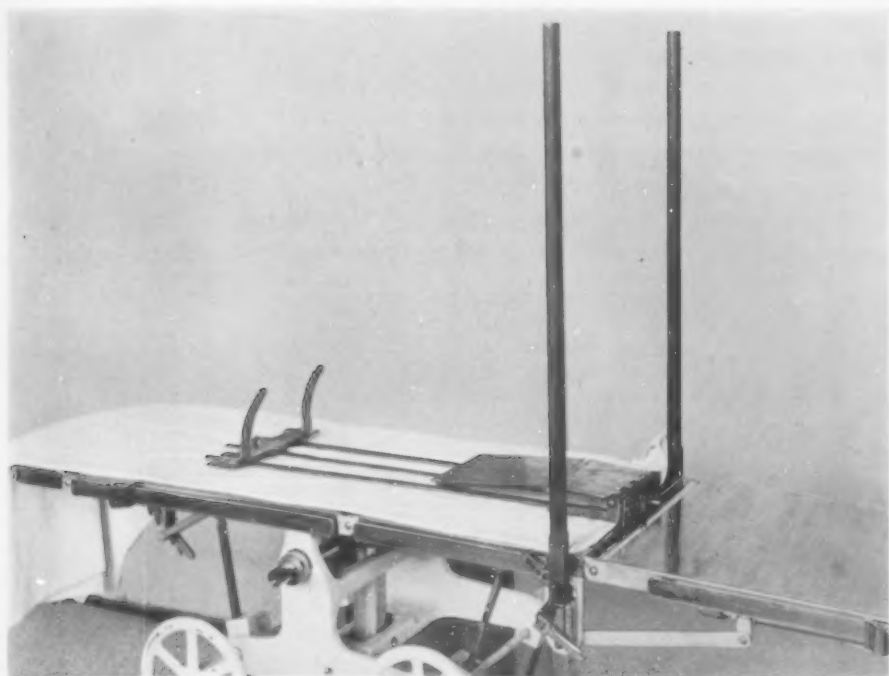
FIG. 3.—Elevator flat on the table, leg pieces in upright position, footpiece raised, ready for reception of patient.
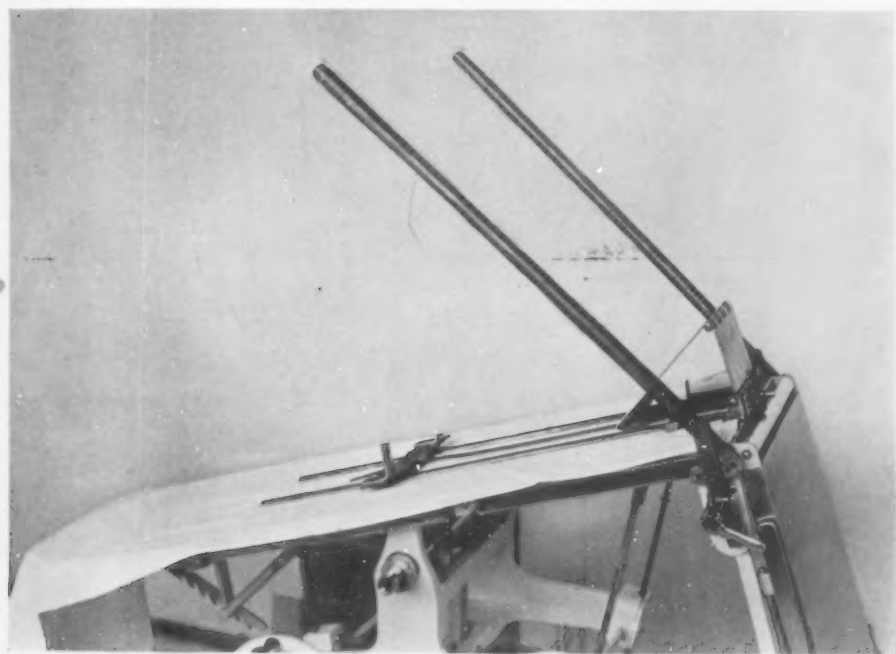

FIG. 4.—Showing elevating planes raised, and the leg pieces depressed ready for the support of the legs.

crank to the screw of the elevator, and raising the elevating planes. Additional elevation may be obtained by lowering the head of the operating table.

The accompanying photographs are illustrative.

This photograph (Fig. 3) shows the elevator flat on the table, with the leg pieces in the upright position. The foot of the table is raised, ready for the reception of the patient.

Figure 4 shows the position occupied by the elevating planes and the leg pieces when the patient is in the elevated position. It will be noticed by
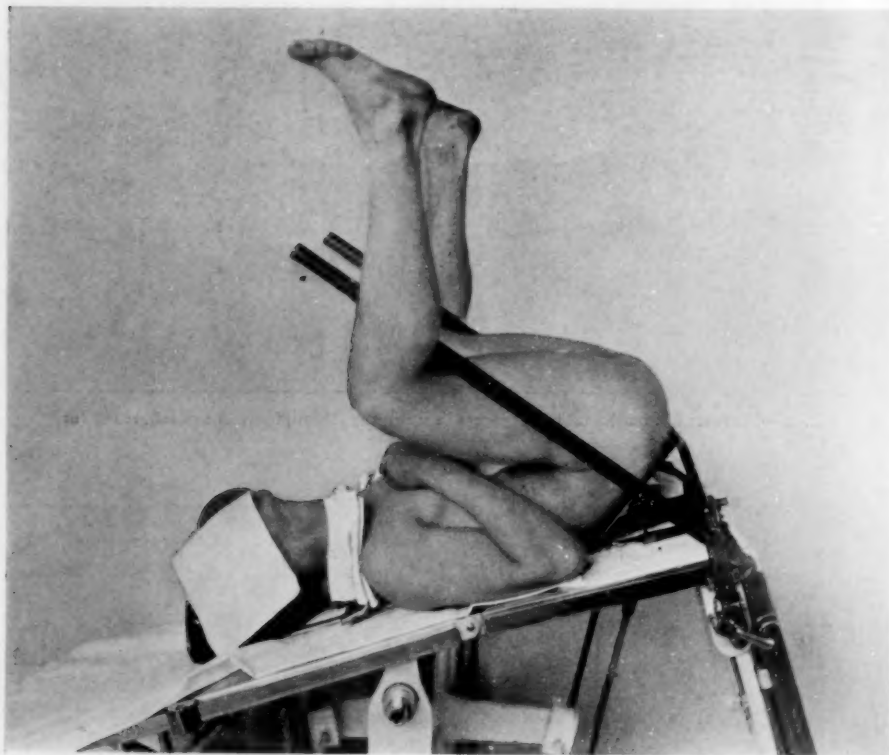
Fig. 5.—The patient in position.

comparing this picture with Fig. 3, that as the elevating planes have been raised, the shoulder braces have advanced a corresponding distance.

The leg pieces are dropped back, and fastened, the footpiece of the operating table lowered, and the head depressed.

Figure 5 shows the patient in position, with the perineum parallel to the floor. Of course, in actual use the leg pieces should be rubber shod, pads should be placed on the elevating planes, and on the shoulder braces. These have been omitted here for clarity of illustration.

While this instrument has been constructed primarily for use in prostatic and seminal vesical surgery, its field of usefulness could readily be extended to rectal surgery, and to gynecological operations through the vagina.

STITCH INTERPOLATION IN ARTERIAL AND VENOUS ANASTOMOSIS

BY CARLETON DEEDERA, M.D.

OF NEW YORK, N.Y.

A SURGEON occasionally needs to anastomose arteries and veins when he may never previously have had any experience in this difficult task. In suturing veins there is a tendency for the lumen to be reduced at the line of suture. Avoiding this is even more important than in operations on the small intestine where the same rules of technic are most useful.

Interpolation is a term of higher mathematics and refers here in a single word to the question of how many stitches to take between certain limits and how deep to take them. In general application in surgery the number and depth are i n v e r s e l y proportional.

It can be stated in the form of a rule as applicable to venous suture as follows:

Rule for Stitch Interpolation.—The depth of the stitch behind the free margin should be equal to the distance between the stitches.

This means that when the suture is drawn to close the line of repair, the tissue between opposite stitch-holes is double the amount of tissue between adjacent stitch-holes.

FIG. 1.—A, shows the J. B. Murphy stitch with arrangement of stitches according to rule for stitch-interpolation. B. This drawing was made from a vein about two to three mm. diameter. The suture material is a raw silk fibre. Knot in this material is smaller than smallest needle and is a great aid. Tension on silk is equivalent to about one-third its tensile strength.

The slight increase in mass thus of tissues in opposition is sufficient to exert pressure laterally and thus counteract tendency to constriction of the lumen.

This is a very simple rule and easy to remember. The experiments upon which it is based were done on dogs, monkeys and goats. In dogs as in the human the distance between stitches in arterial anastomosis should be about twice the thickness of the arterial wall. In venous suture the distance between stitches may safely be three times the thickness of the vein wall.

Although it is not so very common that a surgeon has to suture a blood-vessel, when he does, however, it is usually an emergency. It is for that reason that this rule is offered for publication; that it may help as a determining factor in unexpected cases where the surgeon may never have been confronted with the difficulties in the technic of vascular anastomosis.
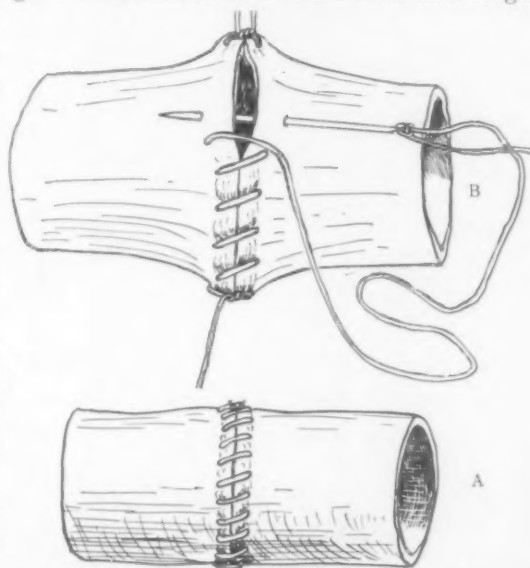
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TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting Held October 5, 1925

The President, Dr. Edward B. Hodge, in the Chair

DIVERGENT DISLOCATION OF THE METATARSUS

Dr. Astley P. C. Ashhurst presented a man, now thirty-five years of age, who was admitted on the night of August 9, 1921, to the Episcopal Hospital, with a recent injury of the left foot: while pushing an automobile the machine began to coast, and one wheel rolled against the upraised heel of the patient, the ball of whose foot rested firmly on the ground, thus crushing the posterior part of the foot against the anterior (Fig. 1). The man felt something give way in his foot, suffered extreme pain, and felt that his foot was more or less crushed. He was put to bed and the foot elevated.
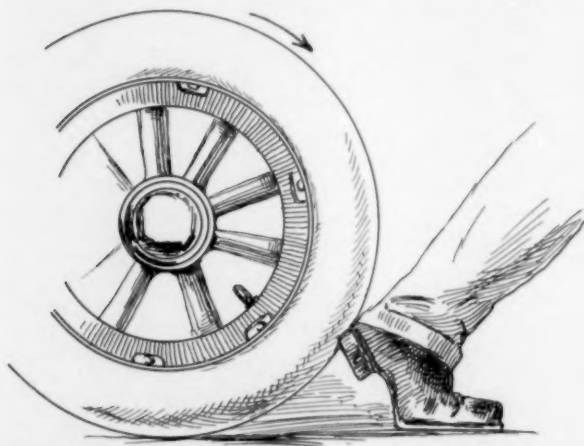

Fig. 1.—Mechanism by which a divergent dislocation of metatarsus was produced in a patient thirty-one years of age.

There was great swelling the next day, the plantar surface of the foot being convex. There was no tenderness over the malleoli or the leg bones. In the region of the base of the first metatarsal or internal cuneiform bone was a bony projection on the median and dorsal aspect of the foot from displacement of the first metatarsal; and on the dorsum of the foot was a bony projection corresponding to the bases of the third, fourth and fifth metatarsals. The swelling was too great to determine anything more accurate by palpation, but a recollection of the brilliant study in 1909 by Quénu and Küss of dislocations of the metatarsus, enabled Doctor Ashhurst to make a tentative diagnosis of a dislocation of *divergent type*, which was promptly confirmed by X-ray study (Figs. 2 and 3). Quénu and Küss (*Revue de Chir.*, 1909, vol. xxxix, p. 1, et passim) showed that the foot may be divided into two structural parts, of which the main weight-bearing part is composed of the tarsus with the first metatarsal and its phalanges, while the four lateral metatarsals with their phalanges serve merely as a balance. They collected thirty dislocations of the metatarsus, and found that there were two main types: (1) that in which the entire metatarsus is displaced laterally and toward the dorsum of the foot (*external dorso-lateral dislocation*), and (2) that in which there is a dislocation of the balancing portion laterally, and of the first metatarsal medially (*divergent dislocation*). Of this latter type, only five cases were

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found in which an uncomplicated divergent dislocation of the metatarsus was present. Speed, in his Text Book, refers to four cases subsequently reported. The present case makes the tenth.

Owing to the condition of the soft parts no attempt at reduction was made for a week. Closed reduction under general anæsthesia being then

FIG. 2.—Divergent dislocation of metatarsus, lateral view.

impossible, open operation was done August 16, 1921, under Esmarch anæmia : a bayonet-shaped incision was made along the course of the peroneus brevis tendon on the lateral border of the foot, thence medially across the dorsum and thence downward along the interspace between the fourth and

FIG. 3.—Divergent dislocation of metatarsus, frontal view.

fifth metatarsals. The bases of the outer four metatarsals were found luxated dorsally and laterally on the cuneiform bones. After elevating the soft parts from the dorsum of the foot, reduction was secured by leverage over a periosteal elevator. Reduction was not maintained, however, until after the peroneus brevis tendon (just above its insertion into the base of the fifth metatarsal) had been sutured into the external cuneiform bone. A

second (longitudinal) incision was then made along the median side of the tibialis anticus tendon and continued downward over the medial surface of the first metatarsal. The base of the first metatarsal was found riding on the dorsal and median surfaces of the internal cuneiform bone. Reduction was easily secured but persistently recurred until the base of the first metatarsal was sutured to the internal cuneiform, by a double strand of No. 2 chromic gut passed through tunnels bored in the bones. The foot was dressed in plaster-of-Paris in the equino-varus position, as this put least strain on the bone sutures. (Figs. 4 and 5.)

The first dressing was made four weeks after operation, when the plaster

FIG. 4.—After open reduction of divergent dislocation of metatarsus.

case was removed, and a felt instep pad was worn in the shoe. Seven weeks after operation the patient walked without crutch or cane, and he resumed his work as bricklayer; his total period of disability from the injury was eight weeks. He has now been at work four years and his foot gives him no trouble.

LATE RESULT (FOURTEEN YEARS) OF ASTRAGALECTOMY FOR FRACTURE-DISLOCATION

DOCTOR ASHHURST said that at the meeting of the Academy, October 2, 1911, he had presented a man, then forty-five years of age, whose astragalus had been broken in two and the fragments displaced anteriorly and posteriorly. Owing to the impossibility of reducing the fragments even by open operation, the entire astragalus was removed. In June, 1925, this patient, now sixty years of age, was again admitted to the Episcopal Hospital with some medical condition. His foot had given him no disability since the accident except some pain in cold and wet weather. There was motion at the ankle-joint

from 80° to 110°; the foot was stable, in good position, and strong. Within a year of operation he had been able to walk eight miles at a stretch. A skiagraph made fourteen years after operation (Fig. 6) shows excessive
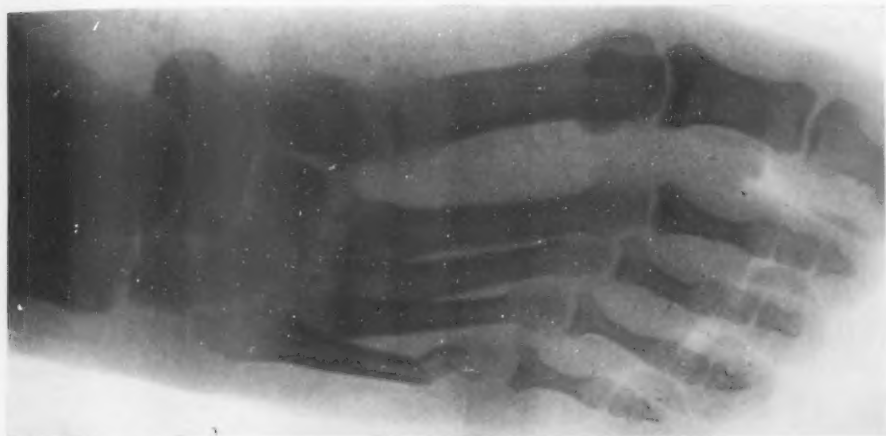
FIG. 5.—After open reduction of divergent dislocation of metatarsus.

bone production from the tibia and os calcis, as well, perhaps as from some minute portions of the astragalus not removed.

FIG. 6.—Fifteen years after astragalectomy for fracture-dislocation.

LATE RESULT (THIRTY-FIVE YEARS) OF EXCISION OF THE ANKLE-JOINT FOR INFECTED COMPOUND FRACTURE

DOCTOR ASHHURST also reported the case of a woman, forty-five years of age, who was seen at the Episcopal Hospital in the summer of 1922. In 1887, when ten years of age, she had been under the care of the speaker's

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father, Dr. John Ashhurst, Jr., in the University Hospital, for a compound fracture involving the ankle-joint, with secondary infection. For this an excision of the ankle-joint had been done by the late Professor Ashhurst, and though the sinuses had been several months in closing, the patient had had no recurrence of trouble, and had been able to lead an active life for the past thirty-five years, and had no discomfort from her foot. There was shortening of the entire lower extremity, amounting to about 8 cm., requiring her to wear a raise on her sole about 5 cm. high, and the foot itself was about a third shorter than its fellow, and inclined a little to the valgus position. There was motion of about 20° in the ankle-joint, the foot being at right angles with the leg. A skiagraph showed absence of the astragalus, with the convex surface of the tibia fitting into a concavity in the calcaneum.

ARTHRODESIS OF THE ELBOW

DR. ASTLEY P. C. ASHHURST read a paper with the above title, for which see page 104.

FOOT DISLOCATIONS

DR. B. F. BUZBY reported the history of a longshoreman who fell down the hold of a vessel fourteen or fifteen feet and sustained a dorsal and lateral dislocation of the foot through the tarsometatarsal joint, all of the metatarsal bones being involved, except the fifth, which was in position. He was given an anæsthetic and the deformity reduced by the closed method and the foot gotten pretty well back into normal position. He stayed in the hospital for about ten days after that and then went home. His later history is not known.

The second case was that of a man who was loading a freight car, when the engine shifted the car and his foot was caught under a steel platform between the freight car and the loading platform. The result was a dislocation dorsally and externally of all of the metatarsals except the fifth, complicated by fracture of all except the fifth. This was reduced by the open method. Post-operative X-ray shows good reduction of the dislocations and fair alignment of the fracture. This was last December and the man now walks around without a cane and without much pain in the foot.

The third case was most unusual. A man was playing golf last November and jumped down from a place about six feet high and says on doing so he was aware that he was about to land in a ditch, and as he fell he gave a lunge forward so as to keep his body at least out of the ditch. When seen by the reporter, not more than an hour after the accident happened, his whole fore-foot was displaced mesially, looking like a congenital club-foot of the varus type.

He had a tremendous amount of swelling. He had a complete dislocation inward of his foot at the mid-tarsal joint. He was taken to the hospital and under anæsthesia the dislocation was reduced. He now is able to play thirty-six holes of golf without rest and says that his function is excellent.

TARSAL RESECTIONS

DR. J. T. RUGH, in connection with one of the cases exhibited by Doctor Ashhurst, said that the results are entirely in harmony with a number of cases of this kind he had seen recently. Morton advocated extensive resection of the tarsals for the correction of club feet from 1886 to 1894. The rule then was to take out as much of the tarsal and metatarsal as was necessary to overcome the deformity, no matter what the age, although more commonly in older patients. About 1894, Wilson reported a large series of these cases.

He had had the privilege of seeing some of the cases done at that time and this astragalectomy done by Dr. John Ashhurst reminded him of them and of the changes that are likely to take place. The immediate result of these mutilating operations for the correction of deformities was good; patients walked on them very satisfactorily just as after astragalectomy, but when the patients come to the age of forty and forty-five years, they are not what is to be desired at all. The secondary changes which take place in the bone after that period of time are at times extremely disabling. Very fortunately, however, the extensive resection operations were only done over a period of about ten years at the most; and the changes seen about the lower end of the tibia and in the tarsal areas recall the changes which are liable to take place in extensive resections.

ARTHRODESIS OF THE WRIST

Dr. Walter G. Elmer called attention to the arthrodesis of the wrist in one of the patients exhibited by Doctor Ashhurst. In children there is some likelihood of a return of motion after this operation has been done. In order to prevent this, he had used a bone-graft from the tibia in several of his cases. After the deformity has been corrected by stretching the contractures and daily manipulation and the hand held in hyperextension upon a splint, a bone-graft is imbedded in the lower end of the radius, the carpal bones and the second metacarpal—extending out to about the middle of the shaft. The hand is in this way firmly ankylosed on the forearm in about 35° of hyperextension. In cases of cerebro-spastic paralysis and of infantile paralysis, the hand is sometimes firmly flexed to a right angle on the forearm. In this position, it is of course entirely useless, as the child has no power to grasp objects. It is quite surprising to see the extent to which they learn to flex the thumb and fingers and to grasp objects after the hand has been fixed in hyperextension. Not only is there some chance of restoring some degree of function, but an unsightly deformity is corrected and the hand placed in a natural and graceful position.

DISLOCATION OF THE ASTRAGALUS

Dr. Edw. T. Crossan presented a woman, thirty-eight years of age, who fell out of a second-story window, landing on both feet. This happened on the first of July. She was admitted to the surgical service at the Episcopal Hospital in Doctor Ashhurst's service. In one ankle there was present an antero-lateral dislocation of the astragalus, while in the other the dislocation was upward (Nelaton's dislocation). The reporter did an astragalectomy two days after her admission to the service. She also had a fracture of the fibula. On the left side she had a badly comminuted fracture of the tibia and fibula and just above the external malleolus the astragalus was dislocated upward. On the other side he used a Delbet splint. The woman states that she now has good motion in the left ankle and good motion in the right ankle, but not as good as on the left side. The astragalectomy was done on the right side; on the left the Delbet splint was used. The Delbet splint was removed to-day and she has begun to walk around the house a little. She is a heavy woman and it will therefore be a longer time till she recovers.

INFECTED HYDATID DISEASE OF THE LIVER ASSOCIATED
WITH CHOLELITHIASIS

DR. E. L. ELIASON presented a man, twenty-six years old, who was admitted to the medical service of the University Hospital in December, 1924, and February of 1925, complaining of sudden acute pain in the epigastrium and back. Each time his pain was relieved within twenty-four hours and he was discharged. He was admitted again in April with another attack of the same symptoms.

For about three years the patient had noticed epigastric distention and belching after eating. He had several attacks of sharp epigastric pain which radiated to the back, and were so severe as to need morphine for their relief. These attacks were associated with nausea and vomiting and slight fever. The present attack, which began a few days before admission, was like the others, except that at this time he first noticed a yellowness, first of his sclera and later of his skin. His stools were light in color, and his urine dark. He had no itching. He felt hot, and weak.

The patient is a Greek by birth, and has lived in America for the past six years. He remembers, as a boy, passing worms by rectum.

When admitted, the patient was deeply jaundiced, and writhing with acute epigastric pain. His chest showed a few basal râles, especially on the right side, and there was diminished expansion at the right base. His abdomen was rigid and tender above the umbilicus, much more marked on the right side. A mass was indefinitely palpable in the upper right quadrant which was believed to be a distended gall-bladder.

Temperature, 98.3°–103°; white blood-cells, 8900. The Van den Bergh test indicated obstructive jaundice. An attempt to drain his gall-bladder by duodenal tube was unsuccessful. No " B " bile was obtained. Pus cells were found in the aspirated duodenal contents.

His abdomen was opened through a right paramedian incision. A markedly distended, thick-walled gall-bladder was disclosed. The gall-bladder was opened and one marble-sized stone was dislodged from the beginning of the cystic duct. The common duct was small, and no bile could be aspirated from it. The duct was opened between catgut tension sutures. Thick, granular bile-colored material was evacuated from it, streaked with pus and fluid resembling an egg with the yolk and white broken up together. A T-tube was inserted in the common duct and a tube was placed in the gall-bladder.

Two days after his operation he developed a broncho-pneumonia or root pneumonia, more marked on the right side—white blood-cells, 18,000.

On the ninth day after operation his chest signs began to grow less marked. His bile drainage which had been free from both tubes grew less from the gall-bladder tubes. Both tubes were removed by his eighteenth day postoperative and his general condition seemed good. He was free from fever for five days.

Three days later he had a return of fever, with some cough, and pain in the lower right chest. White blood-cells, 15,000. The pain continued and a point of tenderness developed over the right ninth rib in the post-axillary line. There was some œdema of the subcutaneous tissues in the same area. The right diaphragm was shown to be high by X-ray. Beneath this an air contained cavity with a fluid level was seen in the liver on the right side from an inch to an inch and a half beneath the diaphragm.

Four weeks after his first operation, the ninth rib was resected in the right post-axillary line. An aspirating needle inserted through the diaphragm into the liver located pus. The wound was packed with gauze. Three

days later, the liver abscess was opened with a cautery, allowing about 8 to 10 fluid ounces of pus to escape. It was noted that several thin-walled cysts escaped, which on examination showed the scolices of the hydatid form of tænia echinococcus. Drains were inserted. The drainage was free from his abscess cavity, at first purulent material, later becoming almost pure yellow bile. A very little bile-stained fluid escaped at the abdominal incision. His stools were clay colored.

About two weeks later, the tube was removed from the abscess drainage tract and his stools began to show bile pigment. The draining wounds rapidly healed. His stools gradually showed more and more bile pigments.

He was discharged from the hospital twenty-four days after his abscess drainage, with both wounds healed and complete relief of jaundice. He has gained 23 pounds.

DOCTOR ELIASON remarked that it had been stated by others that it is extremely hard to keep these cases permanently closed; they will break down from time to time. Many articles speak of the wounds as being infected by the echinococcus.

As soon as he took out the tube in this case, the bile ceased coming out through the fistula and went the normal way. When he first examined this man he could find nothing wrong with the common duct and on putting a needle in it found no bile. He was ready to close him up, but decided to open up the common duct because of the jaundice, and found it filled with material, the like of which he had never seen before. He realized afterward that it was the same as the fluid found in the liver abscess. It looked greatly like a bad egg.

SARCOMA OF THE STOMACH—GASTRIC RESECTION UNDER LOCAL ANÆSTHESIA

DR. E. L. ELIASON presented a man, aged fifty-eight years, who was admitted to the Service " C " of the University Hospital complaining of post-prandial pains, distention, pyrosis, and occasional vomiting; a movable abdominal mass; and loss of weight and strength.

His symptoms dated from January, 1925, when he first began to notice pain following meals, occasional vomiting and marked abdominal distention. Three months later he began to notice a mass above his umbilicus which has gradually grown larger. He has become somewhat costive. At times he noticed that stools were black and tarry, especially during past three months.

Since January (in eight months) he has lost 35 pounds in weight, and he noticed that he was losing his usual strength and vigor. When admitted the man showed marked emaciation. His lungs were clear, and his heart was regular with fairly forceful sounds. The abdomen was scaphoid and thin-walled. Just above the umbilicus was a firm, nodular mass. It was freely movable over the entire upper abdomen, and could be lifted up in the fingers. The mass was not tender. The liver was palpable about three fingers' breadth below the umbilicus on deep inspiration. Its edge was firm, and no nodules were distinguished.

He was operated on September 2, 1925, under local anæsthesia. The upper abdominal wall was infiltrated with ½ per cent. novocaine solution and a right rectus incision was made, disclosing a firm nodular mass about the size of a grapefruit, which involved the pyloric end of the stomach and extended to the duodenum just distal to the pylorus. His liver was free from any

visible or palpable metastatic involvement, and there were no nodules palpable along the lesser curvature of the stomach. A resection of the mass was done after ligating the mesentery in sections. No discomfort was experienced during the resection except when traction was made on the gastro-hepatic omentum, and this was immediately relieved by infiltration with ½ per cent. novocain solution. The duodenal stump was inverted, and a gastro-enterostomy was performed by the Polya method. The loop was brought anterior to the colon because of a short transverse mesocolon. His wound was closed in layers without drainage.

The convalescence was marred only by a slight infection at the site of one hypodermoclysis needle. He had no vomiting or nausea. Water was given by mouth, 36 hours after his operation. He was allowed out of bed on the sixteenth day of his operation, and was discharged on the eighteenth with a well-healed wound and no symptoms. He has since gained ten pounds.

The specimen removed at operation showed very little ulceration of the mucosa, but surrounded the pylorus and the adjacent stomach wall in a hard mass, forming a firm funnel.

On microscopic examination, the tissue was markedly cellular, divided into irregular nests by fibrous bands. It is impossible to recognize any of the stomach layers. At the periphery of the section, there are large deposits of mucoid material, with a few partially degenerated cells. The cells which make up the greater part of the section are round, stain well, and in many instances show vacuoles. The general arrangement, the cell structure and shapes are all indicative of sarcoma. Diagnosis—round-cell sarcoma with mucoid degeneration.

FECAL FISTULA OCCURRING IN A LARGE INCISIONAL HERNIA

DR. JOHN SPEESE reported the history of a man fifty-two years of age, two hundred and sixty pounds in weight, who was admitted to the Presbyterian Hospital, July 29, 1925, for closure of a fecal fistula occurring in a hernia of the abdominal wall. The patient states that he had a tuberculous abscess in the left groin, which was opened twenty-two years ago. There was profuse drainage for eight months when the sinus closed and a year later a hernia developed in the scar. The hernia progressively increased in size, was irreducible, but at no time caused any discomfort. He has worn a combination truss and belt over the hernia which measures approximately 20 x 15 cm. Several days before his admission to the hospital, evidently due to some irritation of the belt, the skin first became inflamed and then ulcerated. This was followed by a discharge of gas and fecal matter in the centre of the ulcerated area. Active peristalsis was seen and felt in the hernia and the skin surrounding the fistulous opening was dirty and ulcerated in appearance. Local antiseptic measures were used in order to overcome the skin infection before operating on the fistula, but owing to the constant escape of fæces such measures were of no avail. Two weeks after his admission to the hospital the fistulous tract in the skin was excised and a minute opening in the small intestine was located. After mobilizing the bowel the fistula was closed by a double row of No. 1 chromicized catgut sutures and the reflected skin sutured over the bowel. Following this operation there was no leakage of intestinal contents and the infection of the skin subsided sufficiently to justify an operation for closure of the hernia. After excising the previously infected skin, the sac was opened by dividing the fascia which covered the hernia for the most part. The protrusion did not involve the inguinal canal and the abdominal muscles were so atrophied and so retracted that they could not be utilized in the closure. The coils of small intestines contained in the sac

were densely adherent to one another and to the peritoneum, from which they were detached with difficulty. After reduction was accomplished, it was found that a firm closure of the opening could be secured by overlapping the fascia. The latter, although strong in the central part, was weak and attenuated at both extremities, and here was reinforced by sutures removed from the fascia lata.

The patient made a satisfactory convalescence, although healing was retarded by a superficial infection which did not interfere with healing of the fascia or prevent a cure of the hernia.

RUPTURE OF AORTA WITH HEMOPERICARDIUM

DR. JOHN SPEESE reported the following case history and exhibited the specimens removed at autopsy: The patient, fifty-eight years of age, was admitted to the Presbyterian Hospital, September 27, 1925, complaining of severe upper abdominal pain. This began twenty-four hours previously and was sudden in onset. The pain began about the level of the costal margin, passed up the sides of the chest to the back of the neck, and was followed by symptoms of shock. His physician gave him three hypodermics of morphine before relief was secured. The following morning he vomited after eating. The pain then recurred, remained localized to the upper abdominal region, was very severe, constant in character, and was followed by persistent nausea and vomiting. He was sent to the hospital with a diagnosis of intestinal obstruction.

On admission the upper abdomen was slightly tender and rigid. Temperature and pulse were both normal. The leucocytic count 15,000. Urine contained many casts and albumen. The patient was admitted late in the evening, passed a fairly comfortable night, and the following morning when examined had little or no pain or tenderness and did not seem acutely ill. Shortly after the examination the severe pain returned and the patient, while reaching for a glass of water, fell back in bed and died.

The autopsy revealed a pericardium markedly distended with soft dark blood clots. The heart was greatly enlarged due to the left ventricular hypertrophy. The arch of the aorta was dilated by an early saccular aneurism. At a point 2.5 cm. above the aortic cusps, there was an irregular jagged tear 4.5 cm. in length involving the wall of the aorta and opening into the pericardium.

The pyloric end of the stomach was remarkably thickened, due to a tremendous hypertrophy of the muscular coats which resulted in marked narrowing of the lumen. There was no evidence of duodenal or pyloric ulcer or other pathologic process which could account for the hypertrophy, which resembles greatly the congenital hypertrophic form encountered in children. The patient had not complained of any gastric trouble or pain prior to the onset of the present attack.

The specimens were shown and the history reported because of the severe nature of the symptoms suggesting upper abdominal disease and because of the presence of such an unusual form of benign pyloric stenosis in an adult. The cause of the latter was not determined, whereas a previous syphilitic history accounted for the disease of the aorta.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

Stated Meeting Held October 14, 1925

The Vice-president, Dr. FRANK S. MATHEWS, in the Chair

CYST OF EXTERNAL SEMILUNAR CARTILAGE

DR. MORRIS K. SMITH presented a man, thirty years old, who entered St. Luke's Hospital in May, 1925. He developed a swelling of the outer side of the right knee four years before. There had been no trauma or other possible etiology that he could recall. At first he had no symptoms, then the knee began to pain. Going up and down stairs became particularly difficult.

FIG. 1.—Tumor removed from the lateral aspect of the external semilunar cartilage of R. N.

Examination revealed a thin man, normal except for the local condition. On the outer side of the right knee, just at the joint level, was a rather firm mass about 1½ inches in diameter. It was not attached to the skin. Active flexion of the knee was limited to 90 degrees, extension was complete. The right thigh was distinctly atrophied, measuring 1 inch less than the left. X-ray examination of the knee was negative.

At operation the tumor was found to be tensely compressed beneath the fascia and attached to the lateral aspect of the semilunar cartilage by fibrous tissue. In cutting it away, a yellowish discoloration of tissue was noted, similar to that found in the tumor itself, suggesting that the disease may have extended into the cartilage, although no other evidence of this was noted. On section (Fig. 1) the growth was made up of multiple cysts with gelatinous content. There were areas of yellowish coloration. The pathological diagnosis was fibroma of knee-joint capsule.

From the day of operation the patient stated that he felt relief. He left the hospital on the eleventh day, and when interviewed recently, five months later, reported the knee to be well. There was no opportunity to examine him at this time.

The reporter stated that Dr. Alan D. Smith of the New York Orthopædic Hospital had described to him a cyst of the external semilunar cartilage which he removed. Phemister's article, "Cysts of the External Semilunar Cartilage," in the *Journal of the American Medical Association* for March 3, 1923, p. 593, describes two cases which tallied so closely with the present one that it seems to represent the same condition.

Phemister's cases are, he states, the first reported in American literature. He collected thirteen from foreign literature. In both of Phemister's cases, the cartilage was involved and was removed. This should be done, as of four cases where the cartilage was left in, in two there was a recurrence, necessitating a later excision.

The man at the time of his presentation before the Society showed a prominence suggesting a recurrence. This is further evidence that the condition originated in the cartilage and it seems probable that he will sometime later have to have it removed.

DR. ALAN DEFOREST SMITH (by invitation) described the case of a young woman with a small swelling on outer side of the knee. At operation, it was found to extend beneath the fascia and was adherent to the lateral semilunar cartilage. This cartilage was removed and sectioned and was found to contain multiple cysts filled with a colloidal material. The pathological examination showed that it resembled the ganglia which are found attached to the capsule of the wrist or the tendon sheath about the wrist. Sections showed a gradual transition from fibro-cartilage to fibrous connective tissue with areas of degenerated tissue which were amorphous in places and then became fluid. The cyst formation was still in progress. Doctor Clarke of the College of Physicians and Surgeons thought that both grossly and histologically it resembled the ganglia which are often found about the wrist.

CHRONIC SYNOVITIS OF THE KNEE-JOINTS

DR. MORRIS K. SMITH presented a child, who in April, 1923, when seven years of age, was first found to have fluid in the right knee-joint. There was a history of trauma to the knee five days before the appearance of swelling. She was seen only twice in the next two months. At the end of this time she reappeared with a swelling of the right knee, said to have occurred the night before. She was under observation for another two months, during which time the fluid was aspirated and the knee treated by a supporting bandage. Guinea-pig innoculation of the fluid was negative. X-ray was also negative. When last examined the right knee measured 1 cm. more than the left. She was next examined in December, 1924, seventeen months later. At this time 100 c.c. of clear straw-colored fluid was aspirated. Guinea-pig innoculation was again negative. Another X-ray was also negative, except for an exostosis in the tibia posteriorly well below the joint level, which did not seem like an etiological factor. Von Pirquet was positive. She was observed throughout the winter. There was complaint of pain in the knee and thigh and in March a very slight temperature having been obtained twice and the local condition remaining little changed, she was referred into the hospital for an exploratory arthrotomy. This was not done, however, as the knee had improved considerably before she was ready for operation. Instead a plaster case was applied. She was last seen in June, 1925. During the winter while the right knee was under treatment, a little fluid was once noted in the left knee.

October 3, she was found to have been perfectly well during the summer, had no pain and could run and play as well as ever. On examination there was fluid in both knee-joints. Aside from the local condition the child's health has been excellent. She has never had rheumatism. Her father has had tuberculosis. Both parents have negative Wassermann reactions.

In this case tuberculosis cannot be ruled out, although it seems unlikely in view of the two negative guinea-pig innoculations, the present bilateral involvement and apparent recurrent character of the affection.

Lues had not been ruled out by the therapeutic test or Wassermann on

the patient, although negative Wassermanns in the parents and absence of other stigmata have made it seem unlikely.

It is possible, although it does not seem very probable, that it may belong to the condition of intermittent hydrarthrosis. No established periodicity has been observed in this patient, however. In a case reported by Nielson in the *Journal of the American Medical Association,* February 18, 1922, there was for some time irregular appearance of the synovitis before a regular cycle set in.

Chronic synovitis is an unsatisfactory diagnosis. The original trauma to the right knee does not seem to have been of great importance. There have been long periods of remission of symptoms, although it is not known whether the fluid has ever completely cleared up.

BLAIR'S OPERATION FOR CANCER OF THE TONGUE

DR. CLARENCE A. McWILLIAMS presented a man of sixty-three, whom he operated upon January 12, 1924, for cancer of the floor of the mouth. The man noticed for four months an ulcer, size of a half-dollar, under the right forepart of the tongue. The ulceration extended to the midline and over to the alveolus. There were a few indefinite enlarged nodes palpable in neck under chin. Wassermann was negative. The patient and specimen were presented with the object of bringing out the thoroughness of Blair's operation, together with its safety as compared with other procedures, also the method of dealing with adjoining bone.

On January 10, 1924, a preliminary tracheotomy was done under local anæsthesia. Two days later the excision (Blair) of the tongue was done successfully,
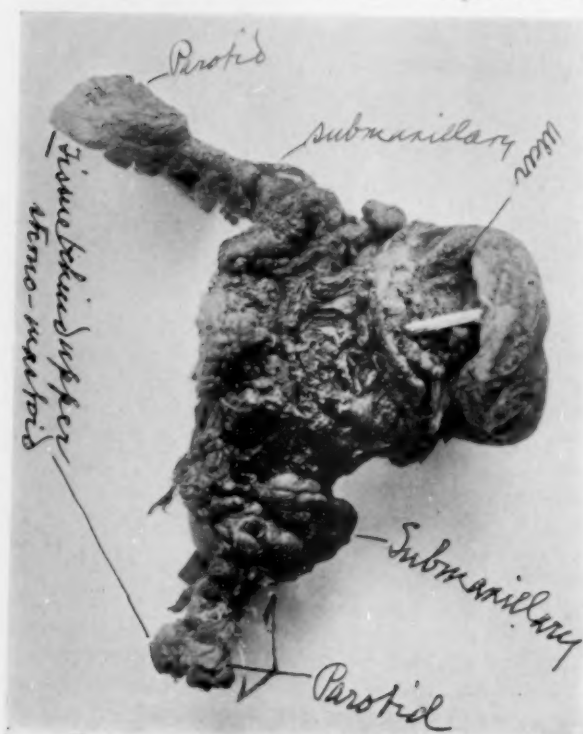

FIG. 2.—Blair's operation for epithelioma of tongue, size of half dollar. Specimen consists of entire tongue with all its intrinsic muscles, lower 1½ inches of both parotids, submaxillary and sublingual glands with the intervening fat, areolar tissues and their contained lymphatic nodes, all removed in one continuous piece.

under colonic anæsthesia (Gwathmey's method). Incision extended from one ear down and forward across the median line, below the hyoid bone to a corresponding point on the opposite side. The skin was dissected up off the platysma, which was removed with the block-dissected tissues, in one piece, including both lower poles of parotids, all the areolar tissue including nodes, both submaxillary glands and the entire tongue with its intrinsic muscles. Below, the digastrics were isolated. The facial arteries

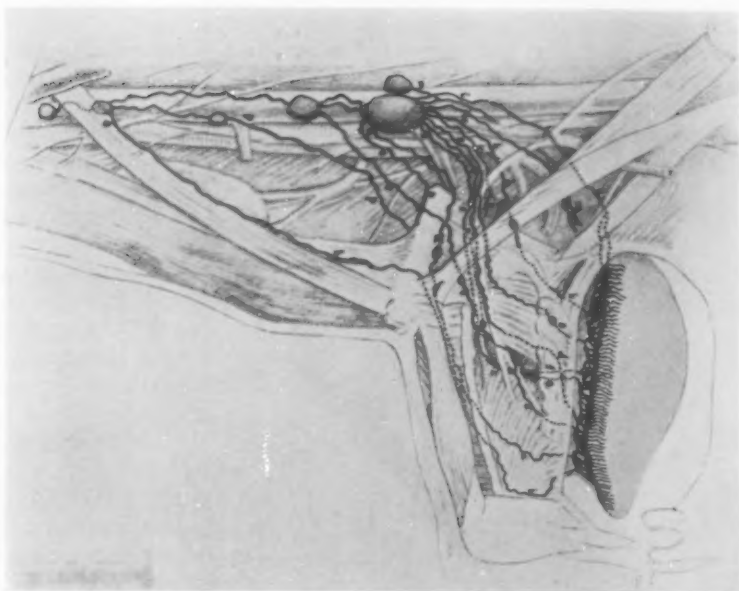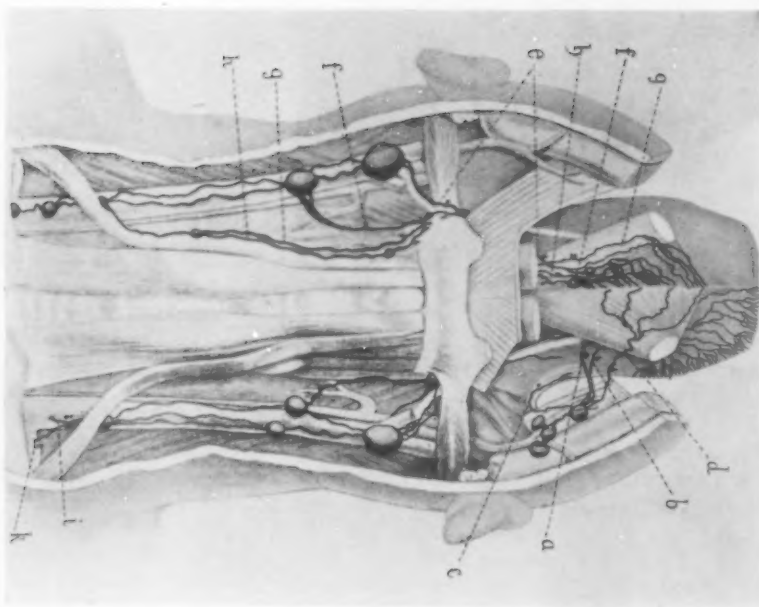Fig. 3.—From Kuttner. Lymphatics draining tongue.

Fig. 4.—From Kuttner. Lymphatics draining tongue.

low down were tied. Just below the front of the outer portions of the digastrics both lingual arteries were exposed and tied by separating the muscular fibres of the hyoglossus muscles. The fascia above the lower edge of the lower jaw was divided all around the jaw, and all the tissues were separated downward from the lower jaw. Beginning at the symphysis pubis, the anterior bellies of the digastrics, the geniohyoids, the geniohyoglossi and the mylohyoids were all divided with a knife closely hugging the bone. The bone adjacent to the ulcer was then thoroughly cooked with a red hot soldering iron. Bone is not easily affected with cancer and experience has shown that unless the cancer has actually grown into the bone, the hot iron will kill enough of the bone to prevent local recurrence there. The tongue is then drawn out below through this wide neck opening and the subsequent excision will depend upon the location of the g r o w t h, the pillars being clearly in view, in necessary cases these and the tonsils can also be removed with the tongue. Before dividing the t o n g u e, the sternomastoid should be dissected out, dividing the spinal a c c e s s o r y nerves, to accomplish good exposure, and the nodes and areolar tissues, beneath the upper parts of the sternomastoids, should all be removed, being attached to and being facilitated by the division of the parotid, $1\frac{1}{2}$ inches from its lower extremity, which is drawn down and forward. Finally the tongue muscles are divided just above the hyoid bone and the base of the tongue divided transversely. The entire specimen is thus removed in one piece. Before closing the external wound, a large catheter is passed through one nostril, being guided past the glottis by a finger in the mouth. The external wound is closed without exterior drainage, but lateral drainage down to the secreting parotids is advisable. The cavity of the mouth is packed with sticky, balsam Peru gauze. The tracheal tube is retained as long as necessary; gradual attempts should be made to swallow until no fluids go down the glottis, feedings being done meanwhile through the nasal catheter. The reporter had expected to clear out the lower cervical nodes of both sides at a subsequent operation, but the man refused to allow him to do this. Upon learning that the ulcer was epithelioma but with only hyperplasia of the upper nodes, he did not insist upon a second operation. A sinus developed subsequently in the neck which led up to dead bone. A large sequestrum developed and this took eight months to loosen and come away.

FIG. 5.—Shows the submaxillary gland of the left side drawn forcefully upward and the facial artery caught and ready to be cut and ligated as it enters the gland. The lingual artery is shown drawn out through a separation between the fibres of the hyoglossus muscle ready for ligation. (Blair.)

This cooking treatment of the bone is much less uncomfortable for the patient than a resection and seems just as curative. Horsley says: " Blair's operation will probably replace other operations for advanced cancer of the

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tongue." Its safety has appealed to the author since he has performed four such operations for advanced cancer of the tongue without a death. Theoretically, one should remove the lymphatics on each side of the neck from the clavicle upwards, doing the procedure in two stages, removing the tongue and the lymphatics to just below the digastrics at the first operation and the two sides of the neck at the second stage.

Bloodgood (*J. A. M. A.,* July 16, 1921, p. 220, and also the same, August 15, 1925, p. 537) has written very fully his experience of thirty years with cancer of the tongue. The situation with this lesion is the same as with cancer of the breast. The prognosis in each depends on the involvement or not of the lymphatic nodes. In cancer of the tongue *without* involvement of the nodes, 62 per cent. (Bloodgood) will be alive five years after operation, but with involvement of the nodes only 10 per cent. will be alive five years. In cancer of the breast about 60 per cent. will be alive after five years without involvement of the nodes, while with node involvement only 20 to 30 per cent. will be alive five years after the operation. Radium may at times favorably affect the local tongue lesion, but Bloodgood says: " I have been unable to find any evidence that Röntgen-rays or radium have accomplished a cure when the nodes are involved." Doctor Bloodgood also says: " I have concluded that the routine complete excision of the nodes of the neck for patients with

FIG. 6.—Specimen from patient two after the Pathologist had finished with it. Ulcer not apparent, owing to curve over tongue. Shows extent of lymphatic area removed in one piece.

early cancer of the tongue is not justifiable by the evidence." The fallacy in this argument is that one can never tell when the nodes are involved, palpation from the outside being notoriously unreliable. Hence the author believes that the only safe rule to make, considering the seriousness of the lesion, is to always excise the nodes of the neck when there is a cancer of the tongue, never mind how small the lesion is, despite negative palpation of nodes.

The neck from the outside is not drained in these patients because it is necessary to prevent the formation of a fistula. There is no drainage in front. The cavity in the mouth left by the removal of the tongue is packed from inside only.

NON-DESCENT OF TESTICLES

Dr. A. V. Moschcowitz presented a man, twenty-two years of age, upon whom he operated for a right undescended testis about six months ago. The testis is now well down in the scrotum and apparently of normal consistency, and of a size which is not smaller than an abnormally placed testis usually is.

The reporter said that a number of years ago he wrote an article describing the pathology and treatment of undescended testis. At that time he was very much inclined to advocate the Bevan operation, going even to the extent of dividing the spermatic vessels. His primary results were excellent. Subsequently Doctor Moschcowitz attempted to reëxamine these patients at late intervals, and while he found some results that were excellent, he found in others, in fact the greater number of them, a very marked atrophy, even to a complete disappearance of the organ. As this could be ascribed only to a complete severance of the vascular structures, this method was abandoned by him. Since a number of years Doctor Moschcowitz has therefore proceeded in the following manner:

The testis is liberated of all the fascial structures as advocated by Bevan. If this is not sufficient to permit an easy transplantation of the testis the internal oblique and transversalis muscles are separated in the upper part of the incision after the method of McBurney. The spermatic vessels are now searched for in the retroperitoneal space and liberated upwards even as far as their origin from the aorta and downwards as far as the inguinal canal. When this has been accomplished there is usually no difficulty in transplanting the testis into the scrotum. He has operated a number of cases by this method with uniformly excellent results.

Dr. Fenwick Beekman expressed his interest in this case because it was the first case, of an adult, he had seen operated on in this manner, for undescended testicle. Formerly he had been doing the Bevan type of operation on children, but had almost invariably had a resulting atrophy of the testicle. Dr. Charles Mixter reported in 1924 a series of cases operated upon by the method Doctor Moschcowitz described, and since that time Doctor Beekman said he had been following the same technic. This operation produced excellent results as the blood supply to the testicle was not disturbed, and if properly done there was no difficulty in getting the testis down into the scrotum. The difficulty of the technic lay in separating the vessels from the thin hernial sac, but as soon as this was done there was little trouble in separating them from the posterior surface of the peritoneum where the lengthening to the cord was obtained.

Dr. Frank S. Mathews said that it was his opinion that the Bevan operation in children would very frequently be followed by atrophy of the testis. Further, he wonders whether there is any evidence that a testis retained in the abdomen will become spermatogenic on transplantation to the scrotum.

Doctor Moschcowitz, in closing the discussion, said that the operation is rather hard, but he had succeeded in doing it and others ought to succeed, for it should be done. He did not believe it was ever followed by any atrophy. As far as the spermatogenesis was concerned this would be hard to prove.

For a long time, whenever he operated on such a case, he always took a small specimen for microscopical examination and in the majority of instances the laboratory reported absence of spermatogenesis. In the literature the statement is made that there is no spermatozoa but that they have a large number of Perdoli cells which go toward the creation of secondary sexual characteristics.

DUODENAL ULCER FOLLOWING GASTRO-ENTEROSTOMY

Dr. Allen O. Whipple presented a man, aged sixty-nine at time of operation, who was operated upon at the Presbyterian Hospital by Doctor Brewer, in January, 1917.

A large mass in region of the pylorus was found adherent to liver and gall-bladder. It was hard, indurated, infiltrating, and was believed to be a carcinoma. Posterior gastro-enterostomy was done.

The patient has been followed for ten years. He has had no digestive disturbances of any sort, he has been free from pain and has maintained his weight. The diagnosis of carcinoma was changed to ulcer of the stomach five years ago.

X-rays taken in May, 1922, seven years later, showed no irregularities or filling defects of stomach or pylorus. The duodenum appeared somewhat irregular about an inch from the pylorus, but it appeared elastic. No evidence of gastric ulcer or carcinoma was made out. The stomach emptied itself both by the pylorus and the gastro-enterostomy.

Last follow-up visit was on November 14, 1924. He then had no digestive disturbances of any sort, no pain after meals, was eating three meals a day regularly.

Gastric analysis made October 13, 1925, was as follows: Total acidity, 70; free HCl, 57.

BLEEDING GASTRIC ULCER. SUBTOTAL GASTRECTOMY

Dr. Richard Lewisohn presented a man, fifty-five years old, who was admitted to Mount Sinai Hospital, June 8, 1925. He had complained of epigastric distress for three years; the pains usually occurred one-half hour after eating. Frequent vomiting for one and one-half years. Typical remissions, lasting for several months. Patient had lost twenty pounds during the last month. He had a slight hæmatemesis with dizzy spells during the last week before his admission.

X-ray examination showed a marked penetration on the lesser curvature of the stomach at the reëntrant angle. The duodenal bulb showed a persistent irregularity. Small residue after six hours. The abnormalities noted were (1) penetration (in view of patient's age carcinoma ought to be considered), (2) irregularity of the duodenal bulb, probably due to a duodenal ulcer. The Ewald test-meal showed: free HCl 22, total acidity 29.

While under observation in the hospital the patient vomited bright red blood, his pulse became very small, the stool showed blood. However, he reacted quickly from this hemorrhage and did not require a transfusion of blood. The hemorrhage recurred five days later (June 16), the hæmoglobin dropping from 75 to 58.

At operation (June 17) a large crater ulcer with marked inflammation of the surrounding tissues was found high up on the lesser curvature. The pylorus and duodenum were normal.

The gastric artery was tied high up on lesser curvature. The finger was inserted into the retrogastric space and adhesions were separated. The gastrocolic omentum was divided below the epiploic arch. The pyloric artery was divided. Clamps were then applied, the upper one about one and one-half inches above the ulcer, and the other one below the ulcer in order to resect as close to the ulcer as possible on account of the high location of the ulcer. The stomach wall was then divided about three-fourths of an inch below the upper clamp, carefully catching the vessels running in the submucosa. The upper end of the divided stomach was protected and drawn aside. Using the remainder of the stomach as a tractor, the duodenum was dissected free. The duodenum was then cut across at about the middle of its first portion and closed in three layers. The upper end of the stomach was then exposed, vessels tied off, and the upper angle sutured for a distance of two inches. A loop of jejunum close to the foramen of Treitz was brought up, passed through an opening made in the transverse mesocolon and placed alongside of the lower angle of the stump of the stomach. The edge of the transverse mesocolon was sutured to the posterior wall of the stomach and an end-to-side gastro-enterostomy was performed. The upper angle of the stomach was inverted by a second layer. The edge of the transverse mesocolon was sutured to the anterior wall of the stomach. The abdomen was closed in two layers and a drainage tube placed into the retrogastric space.

The specimen showed three-fourths of the stomach and the first part of the duodenum, containing a large penetrating ulcer of the lesser curvature, with a crater the size of a twenty-five cent piece. A vessel rose for one-quarter of an inch from the floor of this ulcer. Microscopical examination showed the ulcer to be benign. Ewald test-meal taken July 5 showed: free HCl 0, total acidity 15.

The patient made an uneventful recovery and left the hospital on June 6.

The patient has gained 27 pounds during the last three months.

X-ray examination (October 10) shows a normally functioning stoma.

DOCTOR LEWISOHN stated that patients with profuse gastric hemorrhages should not be operated on immediately, as they are very poor operative risks. However, patients with moderate hemorrhages, as the case just presented, should be subjected to a radical operation at an early date, in order to establish a permanent cure and to safeguard them against a subsequent profuse gastric hemorrhage which may prove fatal.

JEJUNAL ULCER. PARTIAL GASTRECTOMY

DOCTOR LEWISOHN presented a man, forty-six years old, upon whom he had operated at Mount Sinai Hospital in 1918 for a duodenal ulcer. The patient had gastric symptoms for five years, occurring two hours after meals and relieved by food. A duodenal ulcer was found and a retrocolic suture gastro-enterostomy, combined with a pyloric exclusion, was performed.

He was readmitted to the hospital on May 20, 1925, with the following history: He had been free from symptoms for two years. Since then, though with marked remissions, his pains had recurred. He had sour eructations and occasional vomiting. No hæmatemesis.

X-ray examination (May 22): With the ingestion of the barium mixture, the food, after a delay of a few moments, started to pass through the stoma rather slowly. Situated in the jejunum, about one and a half inches from the stoma, was a persistent patch of barium, half-moon in appearance, which measured about three-fourths of an inch in diameter. This had the appearance of a pocket. Gastric tone was good, the peristalsis was increased. The

duodenal bulb was fairly well outlined and an irregularity was seen at the base near the pylorus, which is probably the site of an old ulcer. Gastric motility was delayed, showing a small residue after three hours. Ewald test-meal: free HCl 70, total acidity 85.

Operation, May 23, 1925: A jejunal ulcer was found just beyond the stoma. The ulcer was penetrating and adherent to the transverse mesocolon. The gastro-enterostomy stoma was not involved. The pyloric exclusion had partly opened, admitting one finger. A scar (site of a healed ulcer) was noticed on the anterior surface of the duodenum.

Ligation of the gastric artery and of the left epiploic. The greater omentum was divided between clamps for a short distance, when dense adhesions posteriorly rendered it inadvisable to proceed further. The pyloric artery and right gastro-epiploic were then ligated. The duodenum was cut across and inverted with three layers.

The stomach was cut across just beyond the reëntrant angle and the intrinsic vessels were caught. The stomach was now attached only at the stoma. The stoma was then divided. Because of dense adhesions of the base of the ulcer to the transverse mesocolon (base really formed by transverse mesocolon), the jejunum was cut around the margin of the ulcer. Attempt to infold the ulcer failed. It was touched with tincture of iodine.

The defect in jejunum was closed in the usual fashion in two layers. The upper end of the stomach was closed and a typical Hofmeister anastomosis was performed, using a loop of jejunum distal to the old stoma. The margins of the mesocolon were sutured to the anterior and the posterior wall of the stomach. The abdominal wall was closed in two layers and a tube inserted into the retrogastric space.

The patient made an uneventful recovery.

June 10, Ewald test-meal: Free HCl 0, total acidity 30.

He was discharged June 11. He is well and has gained eight pounds since the operation.

X-ray examination (October 12) shows a normally functioning stoma.

DOCTOR LEWISOHN stated that partial or subtotal gastrectomy was the logical procedure in dealing with gastrojejunal or jejunal ulcers, as local excision of these ulcers was followed by recurrences in a large percentage of cases.

FAILURE OF GASTRO-ENTEROSTOMY TO EFFECT A DECISIVE REDUCTION IN GASTRIC ACIDITY

DR. RICHARD LEWISOHN read a paper with the above title, for which see page 925, vol. lxxxii, December, 1925.

DR. ALEXIS V. MOSCHCOWITZ said he could not absolutely agree with all of the deductions of the paper. It appeared to him that the paper, being entirely of a medical nature, Doctor Lewisohn attempts to draw general surgical deductions and indications. One or two glaring errors have certainly crept in, for instance, the presence of an anacidity in some of the cases of sleeve resection, and yet the so-called acid-producing area and the ulcer-bearing area was not even touched.

DOCTOR MOSCHCOWITZ, particularly in duodenal ulcer, is accustomed to do a very simple posterior retrocolic gastro-enterostomy with a very simple pyloric exclusion and thus far he has been very well satisfied with the

ultimate result and, what is more important. the patient is also satisfied. Once in a great while a gastrojejunal ulcer is encountered, but this occurrence is so rare that it is not a sufficient indication to change his method. As a matter of fact, it appears to Doctor Moschcowitz rather remarkable that there should be such a change in the views regarding the curability of gastric and duodenal ulcer. While Doctor Lewisohn claims a cure by gastro-enterostomy in only about 50 per cent. of the cases, it is generally conceded not only by surgeons, but even the most thorough internists, who are only too prone to check up surgical failures, that at least 80 per cent. to 85 per cent. are cured by simple gastro-enterostomy. The main difference is whereas Doctor Moschcowitz is proud of the 80 per cent. to 85 per cent. cures, it appears to him that Doctor Lewisohn is proud of his 50 per cent. failures.

Dr. Eugene H. Pool thought Doctor Lewisohn had defined very clearly the advantages of anacidity, but did not think he has proved that these advantages compensate for the increased dangers of resection in cases of duodenal ulcer. His arguments are not altogether convincing for the reason that his figures are so much at variance with the figures which have been gathered in every other place where a study has been made of the cures and failures of gastro-enterostomy especially the percentage of marginal ulcers after gastro-enterostomy. This summer the speaker was very much enlightened during a trip to European clinics in seeing the overwhelming tendency toward sub-total gastrectomy for gastric and duodenal ulcers. This is based upon a feeling of the importance of removing the pyloric portion of the stomach to bring about anacidity. In Alessandri's Clinic in Rome he saw the results of experimental studies on the occurrence of marginal ulcers. They reported that in dogs where gastro-enterostomy was performed and the pylorus divided, ulcers developed in a large proportion of cases; but that following gastro-enterostomy and resection of pyloric end of stomach, in no case had marginal ulcer occurred. This, of course, is an argument for gastrectomy, but these ulcers occurred very soon after operation and were not comparable to the chronic indurated ulcers we see in man.

In general the operations upon the stomach were very well done in the European Clinics. There was in von Harberer's Clinic only 4 per cent. mortality with resection. Gosset was one of the few who did not favor partial gastrectomy for duodenal ulcer, but preferred gastro-enterostomy. He voiced the sentiment of most of the American surgeons who were present. He stated that gastro-enterostomy would be the procedure he would elect if he had a duodenal ulcer and said, " What is good enough for me is good enough for my patients."

Dr. Howard Lilienthal said that in 1914 he presented before the International Surgical Society, at its session in New York, a report on 12 cases, in which he had performed operation for duodenal and pyloric ulcer. There was resection of the pylorus with a considerable part of the stomach in two stages, preceding the resection by gastro-enterostomy. He has never had occasion to change his mind as to the proper course in cases of this kind.

He emphasized the point that after gastro-enterostomy a secondary stomach resection can be done with less danger than in a single stage. Therefore, why make a final program until one knows what the less dangerous procedure will accomplish?

Dr. JOHN DOUGLAS said that even if Doctor Lewisohn has proved the failure of gastro-enterostomy to reduce the acidity of the stomach contents, it must be remembered that this is only a part of his general blanket indictment of gastro-enterostomy as a whole. He starts with the subject of the results of drainage after gastro-enterostomy by citing experiments wtih methylene blue and other dyes, and concludes that nearly all the dye went through the pylorus and little through the stoma, which was therefore not effective. In the last edition of Carman's book, as a result of examinations in the Mayo Clinic, he states that after gastro-enterostomy, radiographic examination with an opaque meal, showed that a large proportion of the food rapidly passes through the stoma. In a series of 12 to 14 cases X-rayed after gastro-enterostomy, done at St. Luke's Hospital, the emptying time of the stomach was shorter than it was in a normal stomach. If this is so, one purpose of the operation was accomplished. As to the question of anacidity as a desirable thing, Doctor Lewisohn makes a strong case in stating that jejunal ulcer never occurs in an anacid stomach. But ulcers do occur with low acidity and we have patients with high acidity who never have ulcers. There must, therefore, be another etiological factor beside the acidity. When Doctor Peck read his paper last year the speaker looked up the St. Luke's Hospital records and found that 85 or more per cent. of gastric or duodenal cases were symptom free and a considerable number beyond that of patients who only after indiscretions of diet would have symptoms. As far as the sleeve resection is concerned, Doctor Lewisohn stated that it was followed by anacidity on the basis of three cases. The speaker mentioned one case which continued to have a high anacidity after sleeve resection. While he felt that Doctor Lewisohn had made a case for subtotal resection in gastric ulcer, the speaker considered that it was still questionable whether it is justifiable to do so large an operation for duodenal ulcer when such a large percentage of cures by means of gastro-enterostomy are still being reported from American statistics.

Dr. ALLAN O. WHIPPLE said that in seeing so much radical gastric surgery of the stomach during the past summer on the travel trip mentioned by Doctor Pool, it was a very natural desire on their part to find out what the real results were in these cases of subtotal gastrectomy for duodenal ulcer. They tried to find out what they meant by after-results and discovered that they had no such thing as a real follow-up system. He could get no information of how many cases had been followed. This is a very significant matter, because so much of the influence of the foreign clinics has been brought to bear on the question of the necessity of doing these more radical operations, and a number of American surgeons are doing this radical surgery, for no other reason apparently than that it is being done by well-known

surgeons abroad. The validity of this radical surgery can be decided only by an honest and complete follow-up of these patients over a period of three to ten years.

DR. JOHN F. CONNORS remarked that Doctor Lewisohn said the operation should be governed by three points, the third of which is that it should establish a permanent anacidity in order to prevent the recurrence of an ulcer. Was one to infer from this that in removing the acid-forming area (the pylorus) one had removed the main etiological factor in the formation of ulcer? If this be true, it is a great advance in the treatment of these cases, and would point the way to a much more intelligent mode of procedure.

DOCTOR LEWISOHN, in closing the discussion, said that a strong case against gastro-enterostomy had been made. The mortality following simple gastro-enterostomy at the Presbyterian Hospital was stated to be over 10 per cent. Doctor Lewisohn said that he had performed a partial or subtotal gastrectomy for gastric or duodenal ulcers either by the Billroth I or retro-colic Billroth II method in 33 patients, with one death (mortality 3 per cent.).

The two-stage operation, as suggested by Doctor Lilienthal, was a very good procedure in certain well-selected cases.

The anacidity following sleeve resection suggested further experimental studies which might throw light on the importance of the reëntrant angle as a factor in post-operative anacidity.

BOOK REVIEWS

TUMORS OF THE SPINAL CORD AND THE SYMPTOMS OF IRRITATION AND COMPRESSION OF THE SPINAL CORD AND NERVE ROOTS; PATHOLOGY, SYMPTOMATOLOGY, DIAGNOSIS, AND TREATMENT. By CHARLES A. ELSBERG, M.D., Professor of Neurological Surgery, Columbia University; 8vo, 421 pp. Paul B. Hoeber, Inc., New York, 1925.

DEAR DOCTOR PILCHER:

It is said that the critic is bound by no rules but that he is free to express himself in almost any way that his mood suggests. I am taking this privilege and putting this criticism in the form of a letter, because this book brings up memories of our associations covering now more than forty years. In the early years when I was associated with you as a young man for the ANNALS, when it still carried editorial articles which gave careful summaries of important literary contributions to the science and art of surgery and when it had a department devoted to résumés of important articles in current medical literature, I had the honor of working with you along those lines. You will remember also that for a number of years Pilcher and Lloyd wrote the articles on the Surgery of the Brain, Spinal Cord and Nerves for Sajous' Annual, while I burnt the midnight oil and you passed the manuscript. This association was so delightful and the memories have remained so vivid that I cannot avoid referring to them as I have finished the review of this valuable contribution to the surgery of the spine which Doctor Elsberg has given us.

Few men have had the opportunity of handling, collating and studying 100 consecutive cases of spinal surgery. The book, then, is one that comes from a master in the art, and deserves more than a passing comment. As one reads page by page, one is struck by the valuable suggestions that constantly come out, even in description of the individual cases. As the author says in his preface: " The subject of spinal cord tumors and the symptoms that result from the slowly increasing pressure upon the spinal nerve roots and upon the cord itself, present many features that are of importance not only to the neurologist, but also to the medical practitioner, the orthopædic and the genito-urinary specialists, and the surgeon. To recognize that a pain in the chest is not due to intra-thoracic disease but to a spinal cord irritation; to distinguish between symptoms due to intra-abdominal disease and root symptoms due to spinal disease; to understand the true significance of a brachial, intercostal, or sciatic neuralgia, may be difficult and may tax the diagnostic acumen of the physician. The same statement applies to the differentiation of symptoms of primary disease of the bladder or prostate gland from the rectal and vesical disturbances that occur in spinal disease. Not so rarely patients have been treated for long periods and subjected to operative interference for supposed intra-abdominal or pelvic disease when the cause was in the spinal cord or nerve roots."

Doctor Elsberg throughout the book has evidently had this idea in mind, and we constantly find the emphasis on those symptoms that make differential diagnoses much easier than they formerly were. One cannot but congratulate the author upon the clearness with which he has expressed himself and the care that he has taken to emphasize these questions. How well this is illustrated by the following paragraph: " The compression of the veins of the neck is also a procedure of value during an operation for spinal cord tumor if the growth has not been found in the area of the cord that has been exposed. This procedure, which was suggested by Dr. Jason Mixter, of Boston, permits one to learn during the operation whether the growth is above or below the part of the spinal cord that has been laid bare. If the tumor is above the level exposed, then compression on the veins of the neck will not be followed by a flow of cerebrospinal fluid from higher up; if, on the other hand, the tumor is at a lower level, compression of the jugular veins will cause a free flow of cerebrospinal downward from above." How often in the old days have we gone down upon a supposed carefully located tumor of the spine only to find that it was not in the exposed area; and then have attempted by means of a probe passed up and down to determine whether the tumor was above or below, only to find ourselves blocked by the insufficiency of the data which such a procedure gave?

One has not time nor space to give this book the careful analysis it deserves. We notice that in the operation the author follows the original Abbe technic, in which he cuts down on both sides and frees the spinous processes, and removes them completely by the use of the rongeur forceps. We cannot help but think that the modification of this operation suggested by the writer of this criticism is still an improvement on that technic. In this method, only one side of the spinous processes was denuded, and then by the use of the Liston bayonet forceps, rather than the rongeur, the spinous processes were cut free at their base and left attached to the flap of the other side. This obviates the necessity of cutting through the inter-spinous ligaments. It is true, it may require a somewhat longer incision and the separation of one or two more spinous processes than in the operation where they are completely removed; but, on the other hand, it has the advantage that it retains the inter-spinous ligaments intact, saves the spinous processes which become fixed in the new growth covering the gaps made by the removal of the laminæ, and has other distinct advantages.

His warning about any pressure upon the spinal cord itself in the course of the operative procedure is most timely. Recently we have seen one or two operators who have pushed the cord to one side digitally, necessarily bruising it more or less and with a resulting increase in paraplegia.

The illustrations are well done, and the book has been presented in an especially attractive shape. We not only have to congratulate the author and the publisher, but to thank them for giving us this résumé of such an abundant surgical experience. SAMUEL LLOYD.

THE CIRCULATORY DISTURBANCES OF THE EXTREMITIES, including Gangrene, Vasomotor and Trophic Disorders. By LEO BUERGER, M.A., M.D., New York City. 8vo, 628 pages. Philadelphia and London: W. B. Saunders Company, 1924. Cloth.

In this book, the author has brought together the results of his investigations on the circulatory disturbances of the extremities during the past eighteen years. During this whole period he has written voluminously and well, especially on the subject of thrombo-angeitis obliterans. The profession as a whole has welcomed this work and has tried to keep pace with the investigations but, spread through the literature as it was, it was difficult to follow and required time and labor to hunt out the different articles. This book, embracing as it does the results of his experience and research, is a welcome contribution to our surgical armamentarium.

In his introduction the author outlines his purpose to lay before the reader: first, the anatomy and histology of the normal vascular apparatus of the extremities; second, the anatomy and physiology of the nervous mechanism that controls the vessels; third, a consideration of normal and pathological local circulation; fourth, a comprehension of the origin and action of thrombosis, the mechanical and the thermal agencies on the tissues; fifth, the subject of gangrene in relation to clinical, diagnostic, and pathological aspects; and, sixth, an exposition of the clinical course of all those diseases, whether of organic, vascular, neuro-vascular, or vasomotor causation, that have given and still do give the physician much difficulty in clinical differentiation.

In spite of this very extensive field which the author has laid out for himself, the work is admirably done. His chapters on anatomy are well presented, and the illustrations from Sobotta are clear and distinct. One notices in the chapters on *thrombo-angeitis obliterans* that the author omits the possible etiological factor which has been suggested by several authors, that is the poisoning with carbon monoxide.

We have not seen a work that presented these questions so well as in the present book, and we cannot but congratulate the author on the way he has brought together the views of the different investigators. He has not hesitated to present both sides of any unsolved problem, and the references to the authorities who urge the different theories are carefully given. We must, however, criticize the unusual use of words, as, for instance, the poetic form of often and the use of motivate in place of induce or cause, and other instances of the bizarre use of the English language. However much one may use these in ordinary writing, it is distinctly out of place in a scientific treatise.   SAMUEL LLOYD.

FACIAL SURGERY. By H. P. PICKERILL, C.B.E., M.D., M.S.; Surgeon in charge of Facial and Jaw Department, Dunedin Hospital. With an Introduction by Sir Arbuthnot Lane. New York, William Wood and Co.; Edinburgh, E. S. Livingstone. 8vo, 162 pp., 1924.

This is an interesting book covering the principles of the operations upon the face, giving a good résumé of the war surgery, and an especially good

account of the principles, methods, and technic of plastic surgery. While there are a good many very original operations outlined, still it is interesting to note how, even in a large individual experience, all technic falls back on the principles of facial surgery which have been in vogue for so many years. It is rather interesting to compare the operations in this brochure with those published so many years ago by Szymanowsky, and to note the evolution of the different operations through the years that have passed. The use of the pedicle graft in many of these cases is evidence of a great deal of manual dexterity.

The work is admirably illustrated and is a very valuable contribution to plastic surgery.   SAMUEL LLOYD.

DIE OERTLICHE BETAUBUNG; ihre wissenschaftlichen Grundlagen und praktische Anwendung. By PROF. DR. HEINRICH BRAUN, Leipzig. Barth, 1925.

Braun's original work on local anæsthesia had been so well planned and illustrated in the previous editions of his book that few changes could be expected in this seventh German edition (1925). The sixth edition (1921) has had the good fortune of an English translation last year and the profession has already familiarized itself with the many interesting features it contains.

The first part of the book is remarkably instructive. It is devoted to the history of local anæsthesia and deals with local anæsthetic agents and the various methods of using local anæsthetic drugs. Infiltration and conduction anæsthesia are given the attention which they deserve. Mention is made of Tutocain as a new local anæsthetic drug. It is only in this last feature that the first part of the seventh edition differs from that of the sixth.

The chapter " Operations on the Neck " has been rewritten; the cervical plexus block being replaced by another procedure which is said to be associated with no untoward effects. Injection of the upper poles of the thyroid gland is recommended from two points taken on the surface of the skin. The superficial landmarks are not very accurate and the injection is rather delicate.

The chapter " Abdominal Operations " has been revised and enlarged. Descriptions are given of the technic of splanchnic analgesia by the posterior route (Kappis) and anterior route (Braun) ; the latter being recommended as the procedure of choice.

There has been practically no change along the lines of spinal and sacral anæsthesia which are described under the single heading, " Lumbar and Sacral (Epidural) Anæsthesia."

Spinal (lumbar) anæsthesia occupies a very narrow space and is " restricted in general to operations in regions supplied by nerves from the lower segments of the spinal cord, such as the perineum, sacral region (urethra, prostate, rectum) and legs." The old theory of the diffusion of

the drug to the higher regions of the spine is still alluded to when recommen-
dation is made not to elevate the pelvis. Braun uses novocain-suprarenin
tablets dissolved in physiological salt solution. It is to be regretted that
he made no attempt to discuss the fall of the blood-pressure and completely
ignored the Trendelenburg position during spinal anæsthesia.

Of the methods of blocking the sacral nerves, Caudal or Epidural anæs-
thesia is described, as well as " Parasacral " which is Braun's method of
injecting the sacral nerves on the anterior aspect of the sacrum. No descrip-
tion is given of the transsacral method which, in recent years, has become
so popular in many European countries and in America, especially in surgery
of the bladder, prostate, urethra and rectum.

Failure to include methods which have been given due recognition in
other parts of the world is highly indicative of the expression of personal
experience on which the entire work is based. Although depriving the reader
of descriptions and discussions of some of the latest achievements in local
(regional) anæsthesia, Braun's book remains what it was originally:
a masterpiece.   GASTON LABAT.

SKULL FRACTURES. By WILLIAM H. STEWART, M.D., Röntgenologist
to the Lenox Hill and Harlem Hospitals. Cloth, pp. 64, plates 44, 1925.
Paul B. Hoeber, New York.

This is the sixth volume of a series of monograph atlases, edited by
Dr. James T. Case, under the title of *Annals of Röntgenology.* Those on the
mastoid, gall-bladder, digestive disturbances in infants and children, normal
bones and joints and on the teeth and jaws have preceded it.

It is of the utmost value to have for reference an atlas of the various
types of fracture of the skull, presenting skiagraphs which reproduce exam-
ples so perfectly and with which class of cases the author has had such an
extended experience. Of particular interest is the depiction of those occur-
ring in the base of the skull for which a satisfactory technic has been evolved
which is described in detail in chapter two. The normal röntgenological
pictures of the frontal, lateral and basilar regions are particularly informative
and of especial value when used for comparison in cases where injury
has occurred.

The increasing frequency of occurrence of fractures of the skull, due
especially to automobile accidents, makes the present volume more than
academically valuable, as the medico-legal aspects of accidents involving injury
to the head become so important. Interesting observations are given in
chapter five in the consideration of the time factor of the disappearance of
röntgenographic evidence in fractured skulls. Apparently ossified union in
these flat bones is a comparatively slow process and may vary from six
months to five years, the distance of separation of the fragments apparently
being the determining factor.

Errors into which the observer is likely to fall are carefully considered

and the points in differentiation between fracture and the appearance of unusual venous markings or shadows of grooves on the inner table to accommodate the meningeal arteries, which are in many instances confusing, are noted and well illustrated.

There is no other work on this subject comparable, in scope of consideration and detail and profusion of illustration, to this volume. It must prove of the utmost value not only to the röntgenologist, but to the surgeon and general practitioner and particularly as an authority to be referred to in court proceedings.

In an introductory chapter, Dr. William H. Luckett has made some surgical comments, concluding that all other methods of diagnosing fractures of the skull should, in his opinion, be made subservient to that of the X-ray. His remarks deal chiefly with the relative incidence of fracture of the skull in comparison with fracture of other bones of the body, placing it fourth or fifth on the list (about 7 per cent.), but does not consider the question of surgical intervention in these cases as one might have anticipated.

JAMES T. PILCHER.